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HARVARD COLLEGE
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AN
ESTIMATE
OF THE
TEMPERATURE
OF
DIFFERENT LATITUDES.

By RICHARD KIRWAN, Eſq. F. R. S.

AND MEMBER OF THE ACADEMIES OF STOCKHOLM, UPSAL,
DIJON, DUBLIN, PHILADELPHIA, &c.

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PREFACE.

METEOROLOGY, like every other branch of true philoſophy, dates its origin from the beginning of the laſt century. However deſirous the ancients might have been of cultivating this ſcience; the want of inſtruments neceſſarily denied them all acceſs to it. Drebbel, by the invention of the thermometer, and Torricelli, by that of the barometer, undoubtedly, gave birth to it. From the very origin of the different literary ſocieties of Europe, ſeveral of their moſt diſtinguiſhed members applied themſelves to its improvement: but from the diſcordant multiplicity, as well as imperfection of the inſtruments then in uſe, the narrow limits to which individual obſervations were confined, whoſe importance depends on a knowledge of their extent, the interruption, either by death, ſickneſs, or the common cares of life, of a ſeries, whoſe perplexed concatenation can never be traced, but by an uninterrupted view of its ſucceſſion, ſuch diſcouraging impediments aroſe, as put a period to all theoretic inquiries for many years. There is no ſcience in the whole circle of thoſe attainable by man, which requires ſuch a *conſpiracy*, if I may ſo call it, of all nations, to bring it to perfection as Meteorology; nor is there any, perhaps, more conducive to his ſecurity and comfort. It is not ſufficient that obſervations ſhould be made in one city, in one kingdom, or even in one hemiſphere; but ſimultaneous obſervations muſt, if poſſible, be procured in all degrees of latitude, and longitude, in each hemiſphere, in order that the correſpondence, and connection of the phænomena may be perceived. But in the preſent ſtate of things, to expect all nations to be ſo ſenſible, and attentive to their true happineſs, would indeed be extravagant; ſome ages of civilization muſt firſt elapſe. The only ſovereign who hath hitherto diſtinguiſhed himſelf by his attachment to this ſcience, and thereby inſured to his name the reſpect, admiration, and gratitude of the lateſt poſterity, is that truly wiſe, and excellent prince, CHARLES THEODORE, Elector Palatine of the Rhine; who not only erected an academy in his own principality, ſolely dedicated to meteorological inquiries, but has alſo ſent the beſt inſtruments ſubſervient thereto, fabricated at his own expence, to all the academies and univerſities of Europe, willing and able to undertake the taſk of employing them.

From the diffuſion of that enlightened wiſdom, which already dawns upon almoſt every

European nation, and the deſerved contempt into which the ſavage military prejudices of our anceſtors, the reſult of pride, ignorance, cruelty, and injuſtice, are daily ſinking, it is to be hoped, that other ſovereigns will not be long inattentive to this object, ſo palpably connected with the intereſts of commerce and agriculture, the great ſources of the wealth and happineſs of their reſpective nations. This ſcience differs indeed from other branches of natural knowledge in this; that it does not enable us to alter the ſpontaneous courſe of nature, except in a very few caſes *; but, being brought to perfection, it would, like aſtronomy, enable us at leaſt to foreſee thoſe changes we could not prevent. If from the preſent ſtate of the atmoſphere, the tiller of the ſoil, or of the main, could foreſee, or have a table preſented to him of the changes it would undergo for ſix, or even three months, with what confidence and ſecurity would not each of them be enabled to direct, and purſue their reſpective operations? Great as is the diſtance between ſuch knowledge, and our own preſent attainments, we have no reaſon to think it above the level of the powers of the human mind. The motions of the planets muſt have appeared as perplexed and intricate to thoſe who firſt contemplated them; yet by perſevering induſtry, they are now known to the utmoſt preciſion. The preſent

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* Such as the alteration of temperature, by promoting or checking vegetation, draining moraſſes, &c.

preſent is (as the great Leibnitz expreſſes it) in every caſe pregnant with the future, and the connection muſt be found by long and attentive obſervation.

The firſt ſtep in this comprehenſive inquiry, ſeems to me to be the knowledge of the temperature of the globe, in every latitude. It is the change of temperature that chiefly occaſions the viciſſitudes of winds; theſe in their turns, influence the temperature, and both together form the ſtate of the atmoſphere. Electrical agency, undoubtedly, interferes; but ſtill the temperature affects this alſo, as it does, the riſe, fall, and quantity of vapours, and every other aerial meteor.

The facts contained in the following Eſſay, were collected from the memoirs of the different academies of Europe, and particularly thoſe of the Academy of Medicine, lately erected at Paris, in which the meteorological part is ably conducted, by the celebrated Abbé de la Cotte. The diſſertations of that moſt ingenious philoſopher, Mr. Du Carla, ſome of Mr. Wargentin's, and the excellent Treatiſe on Thermometers, by Mr. Van Swinden, were particularly uſeful to me. I had frequent reaſon to lament the difficulties uncautiouſly ſuperadded to this intricate ſubject. It is a matter of ſurpriſe, that philoſophers have not as yet agreed on one ſort of graduation for their thermometers: beſides that of Fahrenheit, there are now three in uſe on the Continent, that of

Reaumur, the Swediſh, and that of Deliſle. The time requiſite to reduce all theſe to one ſtandard, where the obſervations are numerous, is immenſe; and the three laſt are much more inconvenient for calculation than that of Fahrenheit, as, from the narrowneſs of their ſcales, they preſent more fractions, and expreſs degrees under congelation, by the negative ſign; to this laſt inconvenience, indeed, that of Deliſle is not ſubject; but then its courſe is retrograde to that of all the others: the commencement of its ſcale is variable, and neceſſarily leads to miſtakes.* The diviſion of degrees into lines, and the ſub-diviſion of theſe into twelfths, inſtead of the decimal diviſions, is another inconvenience in barometrical obſervations, which might eaſily be avoided. It were alſo to be wiſhed, that the ſituation of places, their latitude and longitude, the poſition and diſtance of the neareſt ſeas, lakes, foreſts, mountains, &c. were accurately noted, and their uſual names given inſtead of Latin names, which are not to be found in maps, and difficultly known to foreigners. The general deſignations of *hot*, *cold*, *wet*, *dry*, &c. are vague, and preſent no ſort of idea, when no ſtandard is given, to which theſe appellations may be referred. This ſtandard can be no other, than either the mean of the uſual quantities in every country, or that which by experience is found to be moſt neceſſary for its cultivation and ſubſiſtence. Nocturnal obſervations ſeem to have been intirely neglected; yet ſurely they are as neceſſary as the diurnal: this ſhews the neceſſity of ſome public eſtabliſhment for meteorological inquiries. Balloons of a ſmall ſize might be advantageouſly uſed, to diſcover the currents that obtain in the upper regions of the atmoſphere; and if theſe were attended to, particularly about the time of the Æquinoxes and Solſtices, pretty ſure preſages of the enſuing ſeaſons might be had.

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* Would it not be proper to conſtruct a thermometer, beginning at the congelation of mercury, and terminating at the ebullition of water, which might then contain 250 degrees? This I ſubmit to the conſideration of the illuſtrious Meteorological Academy, of Manheim.

The maſs of obſervations already mentioned, I have endeavoured to turn to ſome uſe, in order to pave the way for a theory of winds: the obſervations, in many places, were indeed too few, and the topography of ſeveral others too little known to me; however, I flatter myſelf I have traced a plan, according to which a more perfect ſtructure may hereafter be reared.

CHAP. I.

OF THE SOURCES OF HEAT AND COLD.

THAT the preſence of the ſun is the principal ſource of heat as well as of light, and its abſence of cold, is too obvious to have been ever doubted; neither have mankind been long ignorant of the effect of the greater or leſſer obliquity of its rays. The ſlighteſt attention to their ſenſations during the ſhort period of 24 hours was ſufficient to inſtruct them ſo far; but the immediate and moſt plauſible inference from this ſimple obſervation, though aſſented to for a ſeries of ages, was fully refuted by ſubſequent diſcoveries. The philoſophers of Greece and Italy (the only whoſe writings have been tranſmitted to us) obſerving that in the Summer months, during which in their latitudes the ſun at mid-day is often nearly vertical, the heat was very intenſe, and that in Winter, when its meridian altitude was leaſt, the reſulting cold was equally conſiderable, haſtily concluded that, between the tropics, where its altitude moſt part of the year is nearly vertical, its heat muſt be intolerable, and, for oppoſite reaſons, they judged the countries within the polar circles uninhabitable*. Time among other errors has removed this; but, as uſually happens, it has brought forward other phænomena equally difficult to explain. The hotteſt days are frequently felt in the coldeſt climates, and reciprocally the coldeſt weather, and even perpetual ſnow, are found in countries bordering on, or even immediately under the equator. In the ſame latitudes very different temperatures have been obſerved, not only in different, but even in the ſame hemiſphere. The temperature of the eaſtern coaſt of North America differs widely from that of the weſtern oppoſite coaſt of Europe, but agrees nearly with that of the eaſtern coaſt of Aſia lying between the ſame parallels †; theſe, and ſeveral other phænomena of the ſame nature, leſs remote from us, clearly ſhew we muſt recur to ſome other cauſes beſides the immediate agency or abſence of the ſolar rays.

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* Plin. Lib. II. cap. 68. † Vol. I. Mem. Philadelph.

The celebrated Halley has indeed proved that, abſtracting from the intervention of fogs, miſts, and mountains of ice, the hotteſt weather might in Summer time take place even under the poles, the duration of the Sun's light more than compenſating for the obliquity of its direction; for it is evident that a weak force acting for a long time, may produce as great or a greater effect than a ſtronger force acting for a ſhorter time: but as theſe abſtractions are never realized, and many phyſical cauſes conſtantly obſtruct the activity of the ſolar rays in theſe and other regions, the neceſſity of recurring to ſome other cauſe ſtill remained, until Mr. De Mairan removed the veil *; to him we owe the diſcovery, that the rigour of the Winter's cold is tempered by the heat imparted to the atmoſphere by the earth itſelf: this heat, he ſtyles, in common with ſome celebrated philoſophers of this day, a central emanation, thinking it proceeds from ſome mighty maſs of fire or heat in the center of the earth; a ſuppoſition that appears to me both groundleſs and needleſs. The earth and water were created together, and water, even before the formation of the ſun, was in a liquid ſtate, and conſequently muſt have poſſeſſed at leaſt 32° of our thermometrical degrees; nor could the earth be devoid of heat, otherwiſe the water would have been ſpeedily

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* Mem. Par. 1719 and 1767.

congealed. It appears then, that the globe from its very origin poſſeſſed the heat neceſſary for the purpoſes it was intended to ſerve: this heat indeed would have been long loſt, had it not been preſerved and renewed by the inceſſant influence of the Sun, to which one half of its ſurface is conſtantly expoſed. But as no authentic obſervation informs us that this heat increaſes in proportion as we penetrate below the ſurface of the earth, but on the contrary, many ſhew it to decreaſe (though never to leſs than 36°), and that its variation at the ſame diſtance below the ſurface, conſtantly keeps pace with the variation of the ſolar heat on the ſurface, it ſeems evident that it is to this planet alone, it owes its continuation.

The diſcovery of Mr. De Mairan in great meaſure removed the difficulty of explaining by what means the Winter's cold is ſo far tempered, as to render the colder climates inhabitable; but it went no further; we were ſtill at a loſs to know the mean annual, or monthly temperature of theſe latitudes. I ſay the *mean* or average temperature, for no other is an object of ſcience, as no two ſucceeding years exactly agree in temperature. He has, indeed, with great ſagacity, calculated the *maximum* and *minimum* of heat in every latitude, for the Summer and Winter ſolſtices; but ſo many phyſical cauſes intervene, that the events ſeldom or ever coincide with his calculations, as he himſelf candidly owns.

The famed aſtronomer Tobias Mayer, of Gottingen, in a few pages did more for reſolving all the difficulties that occurred on this ſubject, than any of his predeceſſors *. He firſt pointed out to meteorologiſts, the neceſſity of following the method long uſed by aſtronomers, namely, of firſt finding the mean of certain large periods, as years and months, gradually correcting the errors that may be diſcovered, and afterwards finding an equation whereby to correct aberrations ariſing from height and ſituation. He even proceeded ſo far as to give an equation to correct the effects of height, which in many caſes approximates very nearly; but his moſt important diſcovery ſeems to me to have been the equation, by which knowing the mean annual temperature of two latitudes, the mean annual temperature of every other latitude, and even of the pole itſelf, may be found: this equation, which he has obſcurely and ſummarily delivered, I ſhall give more at large in the following pages.

The defects of Mr. Mayer's method are, 1. That he does not point out the particular ſpace his determinations reſpect, and it is evident they do not indiſcriminately take place every where, for inſtance, in no part of America. 2dly. That he has given no equation to correct the calculation of the temperature of places diſtant from the ſea, nor is his equation

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* Oper. Ined. Vol. I.

for height ſufficiently exact. 3dly. That he gives no account of the monthly temperature. 4thly. That he is totally ſilent with regard to the eaſtern coaſts of Aſia, America, and the ſouthern hemiſphere: theſe, and ſome other, I ſhall endeavour to ſupply.

The next ſource of heat is the condenſation of vapour. It is well known that vapour contains a quantity of the matter of heat, which produces no other effect but that of making it aſſume an aerial, expanded ſtate, until the vapour is condenſed into a liquid; but during this condenſation a quantity of ſenſible heat is ſet looſe, which warms the ſurrounding atmoſphere. This condenſation is frequently cauſed by the attraction of an electrical cloud, and hence the ſultrineſs we frequently experience before rain.

As the earth is the chief ſource of heat in the atmoſphere that ſurrounds it, diſtance from the earth is a ſource of cold; or, in other words, the greateſt cold muſt prevail in the higheſt regions of the atmoſphere, and ſo much the greater, as clear, unclouded air, ſeems to receive no heat whatſoever from the rays of the Sun, whether direct or reflected. Thus if the focus of the moſt powerful burning glaſs be directed on mere air, it does not produce the ſmalleſt degree of heat; and the reaſon is, becauſe the air being tranſparent, affords a free paſſage to the rays of light, which act as fire only when confined within the minuteſt interſtices of bodies; as it is then, and then only, that they counteract the attractive power of the particles of matter; in which action and re-action heat conſiſts.

Hence the higheſt mountains, even under the equator, are during the whole year covered with ſnow. Mr. Bouguer found the cold of Pinchinca, one of the Cordelieres, immediately under the line, to extend from 7 to 9 degrees under the freezing point every morning before ſunriſe; and hence at a certain height, which varies in almoſt every latitude, it conſtantly freezes at night in every ſeaſon, though in the warm climates it thaws to ſome degree the next day: this height he calls the *lower term of congelation:* between the tropics he places it at the height of 15577 feet.

But in lat. 28° he thinks it ſhould commence, in Summer time, at the height of 13440 feet from the level of the ſea. Suppoſing that to be the height of the Pic of Teneriffe, and that this mountain was covered with ſnow in Summer, both which ſuppoſitions the chevalier La Borde has ſhewn to be erroneous, the determination of the height of the lower term of congelation I take to be of great conſequence in meteorology, and therefore ſhall give a table of it for every 5° of latitude.

At ſtill greater heights it never freezes, not becauſe the cold decreaſes, but becauſe vapours do not aſcend ſo high; this height Mr. Bouguer calls the *upper term of congelation,* and under the equator he fixes it at the height of 28000 feet at moſt *.

Under the equator, there being very little variety in the weather, the height of both terms is nearly conſtant; under other latitudes, this height is variable, both in Summer and Winter, according to the degree of heat which prevails on the ſurface of the earth. But as there is a mean annual temperature peculiar to each latitude, ſo there is a mean height for each of theſe terms peculiar to each latitude. And if we take the differences between the mean temperatures of every latitude, and the point of congelation, it is evident, that whatever proportion the difference under the equator bears to the height of either of the above terms, the ſame proportion will the difference peculiar to every other latitude bear to the height of thoſe terms: for a moderate heat diffuſes itſelf in the ſame manner as a great heat, and the diſtance to which their activity extends, will be proportioned to the intenſity of each. Thus the mean heat of the equator being 84, the difference of this and 32, is 52. And the mean heat of lat. 28° being 72,3, the difference between this and 32, is 40,3. Then as 52 . 15577 : : 40,3 . 12072. In this manner, I have calculated the following Tables, which I have inſerted here, as the propereſt

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* The meaſures of every kind mentioned in this Eſſay, are reduced to thoſe in uſe in England.

place, though ſome of the principles on which the calculation is founded, have not yet been given, but may be ſeen, page 17.

LAT.	Mean height of the Lower Term of Congelation. FEET.	Mean height of the Upper Term of Congelation. FEET.	LAT.	Mean height of the Lower Term of Congelation. FEET.	Mean height of the Upper Term of Congelation. FEET.
0	15577	28000	45°	7658	13730
5°	15457	27784	50°	6260	11253
10°	15067	27084	55°	4912	8830
15°	14498	26061	60°	3684	6546
20°	13719	24661	65°	2516	4676
25°	13030	23423	70°	1557	2809
30°	11592	20838	75°	748	1346
35°	10664	19169	80°	120	207
40°	9016	16207			

In this manner, the height of both terms of congelation may be calculated in every latitude, for every degree of heat obſerved at the ſurface of the earth, on which it evidently depends; for when that is at 32°, it is evident the lower line of congelation is alſo on the ſurface.

Hence knowing the height of the lower term of congelation in any latitude, and alſo the general temperature at the ſurface of the earth *, the decrement of heat at any lower

height

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* This is not eaſily known, for it is the mean reſult of a number of obſervations made over a large extent, and of conſiderable duration.

height may be known. For heat is obſerved to diminiſh in aſcending into the atmoſphere, nearly in an arithmetical progreſſion; and in this caſe, we have the firſt and laſt terms; and if we make ſo many terms in the progreſſion, as there are hundreds of feet in the diſtance of the line of congelation, we have all that is requiſite to find the decrement at each term.

Then let L = the intire decrement, or difference between the heat at the ſurface and 32°.

D = the diſtance of the lower line of congelation, in feet.

n = the number of terms = $\frac{D}{100}$

d = the firſt decrement = $\frac{L}{n}$

R = the rank of any given term, whoſe decrement is required.

Then the decrement at any given term = R d; and by ſubtracting this from the heat at the ſurface, we have the heat at that given height. The temperature at the upper term of congelation, may be inveſtigated in the ſame manner, or that of any other height in the atmoſphere, except over mountains; for the air over mountains is generally warmer than air of the ſame height over the ſea, or over plains.

In the neighbourhood of Paris, lat. 48°,50, the temperature of the atmoſphere near the earth being 47°, that, at the eſtimated height of 11084 feet was found by the intrepid Charles, 21°, or 11° below congelation.

Near Dijon, lat 47°, on the 25th of April, the temperature near the earth being 56°, Mr. Morveau found it, at the height of 10631 feet, to be only 26°. It is true, that on the 12th of June, he found his thermometer heated to 70°, at the height of 5280 feet; but his balloon was exceedingly heated by the direct rays of the ſun.

Lord Mulgrave, at the foot of Hackluyt hill, lat. 80, found the temperature of the lower air to be 50°, that, on the ſummit of the hill being 42°: its height was 1503 feet.

Sometimes the temperature of the upper air is higher than that of the lower, particularly when a large maſs of vapour is condenſed by electrical agency; for no part of the heat given out by that cauſe being loſt by communication with air much colder, that which ſurrounds the vapours ſo condenſed, muſt be heated to a conſiderable degree. Air rendered opake by clouds, tranſmits leſs, and conſequently abſorbs more light, and is therefore more heated than clear air. Sometimes winds, in oppoſite directions and different temperatures, flow at different heights, the uppermoſt being often the warmeſt; all which circumſtances, particularly in cloudy weather, render all calculations of the height of the terms of congelation, on any particular day, precarious, though when they regard a particular month or ſeaſon, they may be ſufficiently exact.

The next general ſource of cold is *evaporation*; for the attraction of the particles of liquids decreaſes as their points of contact diminiſh, and thereby their capacity for receiving the matter of heat, (which is the ſame as that of light) increaſes; by this increaſed capacity, the matter of heat or fire contained in the neighbouring bodies, which, like all other fluids, flows where it finds leaſt reſiſtance, is determined to flow towards the vapour; and conſequently thoſe bodies are cooled, though the vapour is not heated; becauſe the re-action of its particles is barely equal to that which it had before its capacity was increaſed.

With reſpect to evaporation, we may remark *, 1. That in our climates, it is about four times as great from the vernal to the autumnal equinox, as from the autumnal to the vernal.

2dly. That other circumſtances being equal, it is ſo much the greater, as the difference between the temperature of the air, and that of the evaporating ſurface is greater; and ſo much the ſmaller, as this difference is ſmaller, and therefore ſmalleſt, when the air and the evaporating liquid are both at the ſame temperature.

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* See 2 N. Com. Petrop. p. 55.

rature. The former part of this propoſition, however, requires ſome reſtriction; for if air be more than 15 degrees colder than the evaporating ſurface, there is ſcarce any evaporation at all; but, on the contrary, it depoſits moiſture on the ſurface of the liquid.

3dly. The degree of cold produced by evaporation, is much greater when the air is warmer than the evaporating ſurface, than that which is produced when the evaporating ſurface is the warmer of the two. For, in the firſt caſe, the dilatation of the vapour is conſtantly increaſed; and, in the ſecond, it is checked. Now the more vapour is dilated, the more fire it abſorbs; and hence it is coldeſt in an exhauſted receiver where it dilates moſt. Hence warm winds, as the Sirocco, Harmatan, *&c.* are more deſiccative than cold winds.

4thly. Evaporation is ſo much the leſs obſtructed by air, as the air is already leſs loaded with vapour. And hence cold winds flowing into warmer countries, powerfully promote it.

5thly. That it is greatly increaſed by a current of air or wind flowing over the evaporating ſurface, not only becauſe the evaporating ſurface is thereby increaſed; but alſo becauſe unſaturated air is conſtantly brought into contact with it. Hence it has been remarked, that calm days are the hotteſt *.

6thly. That tracts of land covered with

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* Mem. Par. 1751, p. 681, 12mo. *edit.*

trees or vegetables, emit more vapour than the ſame ſpace covered with water, as Dr Hales has obſerved. Mr. Williams found this quantity to amount to $\frac{1}{3}$ more *.

Laſtly, We may obſerve, that the heat and cold of different countries are tranſmitted from one to the other by the medium of winds. How the air of a cold country is determined to flow towards a warmer, is eaſily underſtood; but by what means warm air is determined to flow towards cold countries, is ſomewhat difficult to explain. I ſhall here mention three cauſes that occur to me, wiſhing for a fuller explanation from others.

Firſt, If a ſtrong northerly wind prevails in the direction of the meridian oppoſite to London, as in the country of the Tſchutſchi, in the eaſtern extremity of Aſia, this current muſt be ſupplied by air from the north pole; and this in its turn by air ſouth of the pole in the direction of the meridian of London.

2dly. If from any tract in the upper regions of the atmoſphere, two currents of air flow in oppoſite directions, as ſometimes happens, the inferior air being leſs compreſſed, will become ſpecifically lighter; and currents of air in oppoſite directions to the upper currents, will take place.

3dly. I conceive that when eaſterly and weſterly winds meet with unequal force, one of them may be reflected northwards.

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* Second vol. Philadelph. Tranſactions, p. 150.

C H A P. II.

Of a Standard Situation, with whoſe Temperature that of every other may be compared.

FROM what has been already ſaid, it follows, that ſome ſituations are better fitted to receive or communicate heat than other ſituations; thus high and mountainous ſituations being nearer to the ſource of cold, muſt be colder than lower ſituations; and countries covered with woods, as they prevent the acceſs of the Sun's rays to the earth, or to the heaps of ſnow which they may conceal, and preſent more numerous evaporating ſurfaces, muſt be colder than open countries, though ſituated in the ſame latitude; and ſince all tracts of land preſent infinite varieties of ſituation, uniform reſults cannot here be expected. It remains then, that we ſeek for a ſtandard ſituation, with whoſe temperature in every latitude we may compare and appreciate the temperature of all other ſituations in the ſame latitudes, on water only. Now the globe contains, properly ſpeaking, but two great tracts of water, or oceans; one, the Atlantic ſeparating Europe and the weſtern ſide of the old continent from America; and the other, the Pacific, dividing Aſia from America; both of which I divide into north and ſouth, as they lie on the northern or ſouthern ſide of the equator.

In this immenſe tract of water I choſe that ſituation for a ſtandard, which recommends itſelf moſt by its ſimplicity and freedom from any but the moſt permanent cauſes of alteration, viz. that part of the Atlantic that lies between the 80th degree of northern and the 45th of ſouthern latitude, and extending weſtwards as far as the gulf ſtream *, and to within a few leagues of the coaſt of America; and all that part of the Pacific Ocean, reaching from lat. 45° N. to lat. 40° S. from the 20th to the 275th degree of longitude, eaſt of London, which is by far the greater part of the ſurface of the whole globe. Within this ſpace it will be found that the mean annual temperature is as expreſſed in the following table. I have added the temperature of latitudes beyond 80° in the northern hemiſphere, though not ſtrictly within the ſtandard.

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* Dr. Blagden, in an ingenious paper in the Philoſoph. Tranſ. for 1781, has ſhewn that the temperature of this ſtream is conſiderably greater than that of the adjacent part of the Atlantic.

TABLE of the Mean Annual Temperature of the Standard Situation, in every Latitude.

Lat.	Temper.	Lat.	Temper.	Lat.	Temper.
90	31	61	43,5	32	69,1
89	31,04	60	44,3	31	69,9
88	31,10	59	45,09	30	70,7
87	31,14	58	45,8	29	71,5
86	31,2	57	46,7	28	72,3
85	31,4	56	47,5	27	72,8
84	31,5	55	48,4	26	73,8
83	31,7	54	49,2	25	74,5
82	32,	53	50,2	24	75,4
81	32,2	52	51,1	23	75,9
80	32,6	51	52,4	22	76,5
79	32,9	50	52,9	21	77,2
78	33,2	49	53,8	20	77,8
77	33,7	48	54,7	19	78,3
76	34,1	47	55,6	18	78,9
75	34,5	46	56,4	17	79,4
74	35,	45	57,5	16	79,9
73	35,5	44	58,4	15	80,4
72	36,	43	59,4	14	80,8
71	36,6	42	60,3	13	81,3
70	37,2	41	61,2	12	81,7
69	37,8	40	62,	11	82,
68	38,4	39	63,	10	82,3
67	39,1	38	63,9	9	82,7
66	39,7	37	64,8	8	82,9
65	40,4	36	65,7	7	83,2
64	41,2	35	66,6	6	83,4
63	41,9	34	67,4	5	83,6
62	42,7	33	68,3	0	84,

This table is conſtructed on the following principles, which are nearly the ſame as thoſe of Mayer.

Suppoſing the mean annual heat to be greateſt under the equator, and leaſt under the poles, then if the temperature of the equator be m, the temperature of the north pole will be $m - n$, and putting Φ for any other latitude, the temperature of that latitude will be $m - n$ ſin Φ_2.

Now the mean annual temperature of lat. 40°, is found by the beſt obſervations, to be 62°,1, and the temperature of lat. 50°, is found to be 52,9, and this being allowed m and n, conſequently the mean annual temperatures of the equator and of the poles may be determined; for, the ſquare of the ſine of 40°, is 0,41, and the ſquare of the ſine of 50°, is 0,58, both ſufficiently near for the preſent purpoſe.

Then $m - 0{,}41\,n = 62{,}1$

And $m - 0{,}58\,n = 52{,}9$

Therefore $62{,}1 + 0{,}41\,n = 52{,}9 + 0{,}58\,n$.

Whence the value of n is eaſily determined and found to be 53 nearly, and m in the firſt equation is 84; hence the mean temperature of the equator is 84, and that of the pole 31, in number.

With reſpect to the annual temperature, we may remark: 1ſt. That within 10 degrees of the poles the temperatures differ very little; neither do they differ much within 10 degrees of the equator.

2dly. The temperature of different years differ very little near the equator, but they differ more and more, as the latitudes approach the poles.

3dly. It ſcarce ever freezes in latitudes under 35°, unleſs in very elevated ſituations, and it ſcarce ever hails in latitudes higher than 60° *.

4thly. Between latitudes 35° and 60°, in places adjacent to the ſea, it generally thaws when the ſun's altitude is 40°, and ſeldom begins to freeze, until the ſun's meridian altitude is below 40°.

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* 9 Vet. Com. Petrob.

CHAP. III.

Of the Mean Monthly Temperature of the Standard.

IN every latitude, the mean temperature of the month of April, ſeems to approach very nearly, to the mean annual heat of that latitude; and, as far as heat depends on the action of the ſolar rays, the mean heat of every month, is as the mean altitude of the ſun, or rather, as the ſine of the ſun's altitude during that month.

Hence the mean heat of April, and the ſines of the ſun's altitude being given, I find the mean heat of May, by this analogy. As the ſine of the ſun's mean altitude in April, is to the mean heat of April, ſo is the ſine of the ſun's mean altitude in May, to the mean heat of May. In this manner, I find the temperatures of June, July, and Auguſt: but this rule would give the temperatures of the ſucceeding months much too low; becauſe, it does not comprehend the quantity of heat accruing to the atmoſphere by communication of the internal heat of the globe, which in every latitude is nearly the ſame, as the mean annual heat of that latitude. Hence, the real temperature of theſe months, muſt be looked upon as an arithmetical mean, between the aſtronomical, and terreſtrial heats. Thus, in lat. 51°, the aſtronomical heat of the month of September, is 44°,66, and the mean annual heat is 52°,4; therefore, the real mean heat of this month, ſhould be $\frac{44,6 + 52,4}{2} = 48,4$, which is more conformable to obſervation.

It may indeed be ſaid, that not only the ſun's altitude in every month, but alſo the duration of its light over the horizon, ſhould be taken into conſideration. And, without doubt, this, and ſome other circumſtances taken into account by Mr. De Mairan, ſhould not have been omitted by me, if all the circumſtances productive of cold, could alſo be ſubjected to calculation; but ſome of theſe can no way be eſtimated; for inſtance, the cold produced by evaporation: therefore, by way of compenſation, ſome of thoſe productive of heat, ſhould alſo be omitted; and in effect, the approximation of the calculated, to the real heat, is much greater when this element is left out. Thus the temperature of June in lat. 51°, including this circumſtance, is 70°; whereas, in fact, the mean heat of June, in London, is only 63, nor does it exceed 66°, even at Paris, lat. 48° 50′. However, after going through a tedious calculation, I ſtill found the reſults to agree but ill with obſervation; and therefore the enſuing table, is not to be looked upon as deduced from fixed principles, but rather partly from principles, and partly from what appeared to me, after ſtudying a variety of ſea journals, moſt conformable to obſervation. And, as a table of the mean monthly temperatures of different latitudes at ſea, can never be had by obſervation, I flatter myſelf that ſuch a table as this, made as correct as the nature of things will allow, may in ſome meaſure ſupply its place.

TABLE

TABLE of the Monthly Mean Temperature of the Standard from lat. 80° to lat. 10°.

Latitude	80°	79°	78°	77°	76°	75°	74°	73°	72°	71°.	70°	69°	68°	67°	66°	65°	64°	63°
January	22,	22,5	23,	23,5	24,	24,5	25,	25,5	26,	26,5	27,	27,5	27,5	28,	28,	28,	29,	30,
February	23,	23,	23,5	24,	24,5	25,	25,5	26,	26,5	27,	27,5	28,	28,	28,5	29,	30,	31,	32,
March	27,	27,5	28,	28,5	29,	29,5	30,	30,5	31,	31,5	32,	32,5	33,	33,5	34,	35,	36,	37,
April	32,6	32,9	33,2	33,7	34,1	34,5	35,	35,5	36,	36,6	37,2	37,8	38,4	39,1	39,7	40,4	41,2	41,9
May	36,5	36,5	37,	37,5	38,	38,5	39,	39,5	40,	40,5	41,	41,5	42,	42,5	43,	44,	45,	46,
June	51,	51	51,5	52,	52,	52,	52,5	53,	53,5	54,	54,	54,5	54,5	54,5	55,	55,	55,5	55,5
July	50,	50,	50,5	51,	51,	51,	51,5	52,	52,5	53,	53,5	53,5	53,5	54,	54,5	54,5	55,	55,
Auguſt	39,5	40,	41,	41,5	42,	42,5	43,	43,5	44,	44,5	45,	45,5	46,	47,	48,	48,5	49,	59,
Septem.	33,5	34,	34,5	35,	35,5	36,	36,5	37,	38,	38,5	39,	39,5	40,	41,	42,	43,	44,	45,
October	28,5	29,	29,5	30,	30,5	31,	31,5	32,	32,5	33,	33,5	34,	34,	35,	36,	37,	37,5	38,
Novem.	23,	23,5	24,	24,5	25,	25,5	26,	26,5	27,	27,5	28,	28,5	29,	30,	31,	32,	32,5	33,
Decem.	22,5	23,	23,5	24,	24,5	25,	25,5	26,	26,5	27,	27,5	28,	28,	29,	30,	30,5	31,	31,

Latitude	62°	61°	60°	59°	58°	57°	56	55	54	53	52	51	50	49	48	47	46°
January	31,	32,	33,	34,	35,	36,	37,	38,	39,	40,	41,	42,	42,5	42,5	43,	43,5	44,
February	33,	34,	35,	36,	37,	38,	39,	40,	41,	42,	43,	44,	44,5	44,5	45,	45,5	46,
March	38,	39,	40,	41,	42,	43,	44,	45,	46,	48,	49,	50,	50,5	51,	52,5	53,	53,5
April	42,7	43,5	44,3	45,09	45,8	46,7	47,5	48,4	49,2	50,2	51,1	52,4	52,9	53,8	54,7	55,6	56,4
May	47,	48,	49,	50,	51,	52,	53,	54,	55,	56,	57,	58,	58,5	59,	60,	61,	62,
June	56,	56,	56,	56,5	57,	57,	57,5	58,	58,5	59,	59,	60,	61,	62,	63,	64,	65,
July	55,5	55,5	56,	56,5	57,	57,5	58,	59,	60,	61,	62,	63,	63,5	64,	65,	66,	67,
Auguſt	51,	52,	53,	54,	55,	56,	57,	58,	59,	60,	61,	62,	63,5	64,	65,	66,	67,
Septem.	46,	47,	48,	49,	50,	51,	52,	53,	54,	55,	56,	57,	58,5	59,	60,	61,	62,
October	39,	40,	41,	42,	43,	44,	45,	46,	47,	48,	49,	50,	50,5	51,	52,	53,	54,
Novem.	34,	35,	36,	37,	38,	39,	40,	41,	42,	43,	44,5	46,	46,5	47,	48,	49,	50,
Decem.	32,	33,	34,	35,	36,	37,	38,	39,	40,	41,	42,	44,	44,5	45,	46,	47,	48,

Latitude	45°	44°	43°	42°	41°	40°	39°	38°	37°	36°	35°	34°	33°	32°	31°	30°	29°	28°
January	44,5	45,	45,5	46,	46,5	49,5	51,	52,	53,5	55,	56,5	59,5	63,	63,	63,	63,5	63,5	63,5
February	46,5	47,	48,	49,	50,	53,	56,5	58,	60,	61,	62,	63,	64,5	66,	67,	68,5	68,5	69,5
March	54,5	55,5	56,5	58,5	59,5	60,	60,5	61,	62,	63,	64,	65,	66,5	67,5	68,5	69,5	71,	72,
April	57,5	58,4	59,4	60,3	61,2	62,1	63,	63,9	64,8	65,7	66,6	67,4	68,3	69,1	69,9	70,7	71,5	72,3
May	63,	64,	65,	66,	67,	68,	69,	70,	70,5	71,	71,5	72,	72,5	73,	73,	73,5	74,5	75,5
June	66,	67,	68,	69,	70,	70,5	71,	71,	71,	71,5	71,5	72,	72,5	73,	73,	73,5	74,5	75,5
July	68,	69,	69,5	70,	70,	71,	71,	72,	72,	72,5	72,5	72,5	72,5	73,	73,	73,5	74,5	75,5
Auguſt	68,	69,	69,5	70,	70,	71,	71,	72,	72,	72,5	72,5	72,5	72,5	73,	73,	73,5	74,5	75,5
Septem.	63,	64,	66,	68,	69,5	70,5	71,	71,5	72,	72,5	72,5	72,5	72,5	73,	73,	73,5	74,	75,5
October	55,	56,	57,	58,	59,	60,	61,	62,	63,	64,	65,	66,	67,5	68,5	69,5	70,5	71,	72,5
Novem.	51,	52,	53,	54,	55,	56,	57,	58,	59,	60,	61,	62,	63,	64,5	65,5	66,5	68,	69,
Decem.	49,	50,	51,	52,	53,	54,	55,	56,	57,	58,	59,	60,	61,	62,5	63,5	64,5	66,	67,

Latitude	27°	26°	25°	24°	23°	22°	21°	20°	19°	18°	17°	16°	15°	14°	13°	12°	11°	10°
January	64,	64,5	65,5	67,	68,	69,	71,	72,	72,5	73,	73,5	74,	74,5	75,	76,	76,5	77,	77,5
February	69,5	70,5	71,	72,	72,	72,5	74,	75,	76,4	76,5	77,	77,5	78,	78,5	79,	79,5	79,8	80,
March	72,5	73,	73,5	74,5	75,	75,5	76,	77,	77,5	78,	78,5	79,	79,5	80,	80,8	81,	81,5	81,8
April	72,8	73,8	74,5	75,4	75,9	76,5	77,2	77,8	78,3	78,9	79,4	79,9	80,4	80,8	81,3	81,7	82,	82,3
May	76,	76,5	77,5	78,	78,5	79,5	80,	80,5	81,	81,5	82,	82,5	83,	83,	83,5	84,	84,	84,3
June	76,	76,5	78,	78,5	79,	79,5	80,	80,5	81,5	82,	82,5	83,	83,5	83,8	84,	84,3	84,6	84,8
July	76,	76,5	78,	78,5	79,	79,5	80,	80,5	81,5	82,	82,5	83,	83,5	83,8	84,	84,3	84,6	84,8
Auguſt	76,	76,5	78,	78,5	79,	79,5	80,	80,5	81,5	82,	82,5	83,	83,5	83,8	84,	84,3	84,6	84,8
Septem.	76,	76,5	77,5	78,	78,5	79,	79,5	80,	81,	81,5	82,	82,5	83,	83,	83,5	84,	84,3	84,6
October	72,5	73,	73,5	74,5	75,	75,5	77,	78,	79,	80,	81,	81,5	82,	82,5	83,	83,5	83,8	84,
Novem.	69,5	71,5	72,	73,5	74,	74,5	75,	75,5	76,	77,	78,	78,5	79,	79,5	80,	80,5	80,8	81,
Decem.	67,5	68,5	69,5	70,5	71,	71,5	72,	72,5	73,	74,	75,	75,5	76,	76,5	77,	77,5	78,	78,5

Though the ſun is one month abſent in lat. 67°, and two months in lat. 70°, &c. yet I have ventured to ſet the mean heat of January, in lat. 70°, no lower than 27°, becauſe at Wadſo, lat. 70° 5′, the ſea is never obſerved to freeze, and its temperature is generally about Chriſtmas, at 32°, ſometimes above and ſometimes below it: Mem. Stock. 1753. Froſt, ſcarce ever lies on the Orkneys, lat. 59°; and that excellent meteorologiſt, Mr. Reyer, relates, that at Archangel, lat. 64°, in October, a ſoutherly wind is much colder than a northerly. He alſo obſerved, that in Dantzick, lat. 54, even in the month of January, a north wind brings on a thaw, or at leaſt moderates the froſt, whereas a ſoutherly wind is intenſely cold*: which ſhews, that the north Atlantic is not ſo cold as is generally imagined; for the Baltic is certainly colder in Winter, than the Atlantic in the ſame latitude. From this table we may learn,

1ſt. To find the mean heat of the firſt, and laſt half of any month.

Find the mean betwixt the ſtandard heat of any month, and the ſtandard heat of the ſucceeding; this will be the mean of the laſt 15 days of the preceding, and the firſt 14 or 15 days of the ſucceeding month.

2dly. To find the uſual extremes whether of heat, or of cold, that take place in any month.

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* 2 Abhaudlung. in Dantzic, p. 143.

Find the difference of the monthly and annual temperatures; this difference *added* to the monthly temperature, gives the temperature of the hotteſt day, that is uſually found in any month; or being *ſubtracted* gives the coldeſt day, uſually obſerved within the month: by day, I mean the ſpace of 24 hours. Thus in London, the annual temperature being 52°, and the temperature of Jan. 36°, the difference is 16, conſequently the warmeſt day in January is 52°, and the coldeſt 20°.

The greateſt cold within the 24 hours, generally happens ½ an hour before ſunriſe, in all latitudes. The greateſt heat in all latitudes between 60° and 45°, is found about ½ paſt 2 o'clock in the afternoon; between lat. 45° and 35°, at 2 o'clock; between lat. 35° and 25°, at ½ paſt; one and between lat. 25°, and the equator, at 1 o'clock.

On ſea, the difference between the heat of day and night, is not ſo great as on land, particularly in low latitudes.

The coldeſt weather in all climates, generally prevails about the middle of January, and the warmeſt in July, though, aſtronomically ſpeaking, the greateſt cold ſhould be felt at the latter end of December, and the greateſt heat in the latter end of June; but the earth requires ſome time to take, or to loſe the influence of the ſun, in the ſame manner as the ſea with reſpect to tides, does that of the moon.

CHAP. IV.

Of the Difference of Temperature of Air, Land, and Water, and of their Capacities of receiving, and tranſmitting Heat.

AIR, when perfectly clear and tranſparent, receives very little heat from light, as has been already ſaid; but, if cloudy, it is capable of receiving much more, and hence cloudy air is often warmer than the earth over which it is incumbent. Air, is alſo often warmed, by the condenſation of the vapours interſperſed through it, particularly when this condenſation ariſes from electrical agency, and by theſe means the upper ſtrata of the atmoſphere, are often warmer than thoſe which are ſomewhat lower; and hence, the origin of hail, which is rain condenſed by paſſing through air colder than that in which it was produced; but the greater part of the heat of the atmoſphere, is certainly derived from its communication with the land, or water, over which it ſtands, and in this way it receives, either heat, or cold, more readily than any other body of the ſame bulk, particularly if it be confined, as in vallies; but it conducts theſe qualities to or from other bodies, very ſlowly, as the points of mutual contact, are inconſiderable.

able. Snow, falling from the higher regions of the atmoſphere, is generally colder than the lower air; which, therefore, after a fall of ſnow, is often colder, than air 30 or 40 feet above the ſurface, as appears from the experiments related by Mr. Wilſon in the Philoſophical Tranſactions of the year 1780.

Air, incumbent on ſeas, or on large tracts of water, is generally many degrees warmer in Winter, and cooler in Summer, than air incumbent on land, becauſe land is more ſuſceptible of both heat and cold, than water; and, in general, air participates of the temperature of the ſubſtances with which it is in contact.

The capacities of land and water for receiving heat, or cold, are very different. *Land*, or *earth*, particularly if dry, receives heat from light very readily, but tranſmits, or conducts it through its own ſubſtance, to great depths, very ſlowly; whereas water, by reaſon of its tranſparency, receives heat from light very ſlowly, but what it receives, is diffuſed through it much more readily. Dr. Hales found that in the month of Auguſt, 1724, when the air and the ſurface of the earth were both at 88°, a thermometer placed only 2 inches under the ſurface, ſtood at 85°; and another 16 inches under the ſurface, indicated 70°; and another 24 inches deep, 68°. Theſe two laſt mentioned thermometers, preſerved the ſame temperature both day, and night, until the end of the month, and then fell only to 63° or 61°; ſo obſtinately did the earth, at that depth, retain its heat, though the temperature of the air frequently varied*.

On the 26th of October, a thermometer expoſed to the air, ſtood at 35°,5; but one ſunk 2 inches in the earth, was heated to 43°,85; another ſunk 16 inches, ſhewed 48°,8; and one at the depth of 24 inches, 50°; he even found, that between the 1ſt and 12th of November, when the external air was cooled ſo low as 27°, another thermometer placed at the depth of 24 inches, ſtood at 43°,8; but from the month of March, to that of September, of the following year, the external air was conſtantly warmer, than the earth at the depth of 16 inches, or 2 feet; but the ſeaſon was very rainy, and the evaporation occaſioned thereby, prevented the earth from being warmed, ſo much as it otherwiſe would have been. However, theſe experiments clearly prove, 1ſt. That the ſurface of the earth is much heated during the Summer, but that this heat deſcends very ſlowly, a great part of it being communicated to the air. 2dly. That during the Winter, the earth gives out to the air, the heat it had received during the Summer. 3dly. That wet Summers, muſt be ſucceeded by cold Winters.

Theſe experiments agree very well with thoſe of Mariotte, who found, that the earth is gradually heated during the Summer, and as gradually cooled during the Winter months, and that, at the diſtance of a few feet under the ſurface, it is conſtantly warmer than the external air; this exceſs he found to remain until April, when the ſurface is again heated by the ſun's rays, and ſlowly tranſmits its heat downwards. In all this, we ſee nothing like the operation of a central heat. *

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* Hales Veg. Stat. p. 61.

Hence at a certain diſtance from the ſurface, namely, about 80 or 90 feet, (if this depth has any communication with the open air, and perhaps, at a much leſs depth, if there be no ſuch communication) the temperature of the earth varies very little, and generally approaches to the mean annual heat. Thus the temperature of ſprings, is nearly the ſame as the annual temperature, and varies very little in the different periods of the year, as Mr. Hellant has firſt obſerved. Thus alſo the temperature of the cave of the obſervatory at Paris, about 90 feet below the pavement, is about 53,5 degrees, and varies about ½ a degree in very cold years. Its temperature is ſomewhat above the mean temperature of Paris, on account of its communication with the external air. Mr. Van Swinden has obſerved that the greateſt cold, even that which exceeds 0 of Fahrenheit, if it laſts only a few days, penetrates no deeper than 20 inches,

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* Mariotte ſur le Froid & le Chaud, p. 189.

even when the earth is not covered with ſnow, and not above 10 inches where ſnow lies on the ſurface; by which we learn the important purpoſes this covering anſwers in high northern latitudes. In Siberia, where the cold is known to be ſo intenſe, immediately after the melting of the ſnow, the earth is found unfrozen, not only at its ſurface, but even to the depth of 16 feet, which ſhews that ice never penetrates into it, except in a very few places. By an obſervation made at the bottom of a mine lying between Calais and Boulogne, 476 feet beneath the ſurface, the temperature was 54° *. The temperature of the ſalt mines at Wicliczka, in Poland, is 52° at the depth of 320 feet; and from thence to the depth of 716 feet, it does not vary †, though the temperature of mines is ſubject to changes from cauſes that are peculiar to them: thus Mr. De Luc, at the depth of 801 feet in the mine of St. John in the Hartz, experienced a heat of 70°; but at the depth of 1359 feet, he found it no greater than 50° ‡. Kraft obſerved the temperature of a cavern near Reutling, in Suabia, to be 48°, but water in the ſame cavern, was heated only to 42°, the external air at that time being at 66° ‖. The mine of Joachimſtahd in Bohemia, is reputed one of the deepeſt exiſting;

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* 3 Act. Helvet. p. 27. † Guettard Mem. Par. 1762, p. 1087 and 1089, 8vo. Edit. ‡ Phil. Tranſ. 1779, p. 502. ‖ Mem. Petrob. 144.

in this, Mr. Monnet found the temperature, at the depth of 1700 feet, to be 50°*.

All theſe facts, tend to prove that the heat of the earth does not increaſe as we deſcend into it, but at the greateſt depths, is nearly the ſame, as the mean annual temperature of the latitude. When the ſurface of the earth is cooled rapidly, the interior parts are cooled proportionably, to a certain depth, until the cold of the ſurface arrives at its maximum, and becomes conſtant; then the internal heat gradually gains upon it, with a force proportioned to their difference of temperature; and as in our climates, the internal heat is always above 40, it is always ſufficient to melt the ſnow that lies long on the ſurface. Hence in Swiſſerland, and many other countries, ſnow is obſerved to melt firſt at the bottom.

Land, is capable of receiving much more either heat, or cold, than water. In the neighbourhood of Marſeilles, Dr. Raymond found land often heated to 160°; but he never found, the ſea hotter than 77°, and even this heat it receives chiefly by communication with land; for, on the 19th of July 1765, he found that part of the bay next the land heated to 74°, the middle of the bay being at 72°, and the entrance of the bay 70°. In Winter he frequently obſerved, the earth cooled down to 14° or 15°, but the ſea never lower than 44°, or 45°; [*] and the reaſon is, not only, becauſe water is incapable of receiving much heat from light, as already ſaid, but becauſe it is conſtantly cooled by evaporation. In Winter, when the ſurface is much cooled by contact with colder air, the deeper and warmer water of the bottom, being ſpecifically lighter, riſes and tempers it; and as the colder water conſtantly deſcends during the Winter, hence it is, that in the ſucceeding Summer, the ſurface is generally warmer than at greater depths, whereas in Winter, it is colder; hence alſo it has been remarked, that after a ſtorm, the ſea is always warmer in Winter, and colder in Summer, the water of great depths being then mixed and incorporated with that of the ſurface [†].

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* 10. Roz. 234.

N. Lat.			Heat at the Surface.	Depth. Feet.	Heat.
70°	May	12	36°	502	39
		17	37°	540	39
	June	9	44°	558	40
	July	7	46°	420	44
68°		8	47°	1560	52
65°		9	48°	1280	48
		10	52°	846	45 [‡]
27°	Jan.	3	64°	540	58 [§]
0			84°	3600 & 5346	53 [‖]

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[*] Mem. de la Societe de Med. de Paris, An. 1778, p. 70.

[†] Suenſk. Handling. 1753.

[‡] Phil. Tr. 1770. p. 39.

[§] 2 Bergm. Erde Kugel, p. 119.

[‖] Phil. Tr. 1752. p. 213.

But Lord Mulgrave found the temperature of the ſea, at great depths, in high latitudes, much colder; he does not indeed mention, the temperature of the ſurface, but it is preſumed, it did not differ much from that of the air; perhaps the reaſon was, that the newly melted ice, had then deſcended, though the firſt experiment cannot be explained, even on that hypotheſis.

Lat. N.		Heat of Air.	Depth.	Heat of the Sea.
67°	June 20	48°,5	4680	26°
78°	30	40°,5	708	31°
69°	Aug. 31	59°,5	4038	32°

Obſervations of Meſſrs. Wales and Bayley.

Lat.		Air.	Surface.	Depth. Feet.	Heat of the Sea.
0	Sept. 5	75°,5	74°	510	66°
24° S.	26	72°,5	70°	480	70
34°44′	Oct. 11	60°,5	59°	600	57°

Obſervations of Mr. Bladh.*

57° N.	Jan. 8	46°	37°	6	40°
	10	43,6	43,6	50	43,6
55.40	20	47	40	110	51,5
39.30	28	53	59	110	59
2.55	Feb. 25	81	81	58	81
2.50	26	83	84,5	110	81

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* Suenſk. Handling. 1781.

Mr. De Sauſſure, in the month of Auguſt, found the temperature of the lake of Geneva, at the depth of 87 feet, to be about 55° of Fahr. while at the ſurface it was 62°, the heat of the air being 81°. In Winter, the temperatures of the ſurface and bottom, are nearer to an equality; thus in the month of February, after a froſt that had laſted a month, the air being at 38°, the ſurface of the lake was at 41°, and at the depth of 1000 feet, the temperature was 40, probably from a mixture of ſnow water.

As the water in the high northern and ſouthern latitudes, is, by cold, rendered ſpecifically heavier than that in the lower warm latitudes, hence there ariſes a perpetual current from the poles to the equator, which ſometimes carry down large maſſes of ice, which cool the air, to a great extent. It is certain that inland ſeas, of great extent, have been frozen in very ſevere Winters; thus the Baltic was ſo firmly frozen in 1668, that Charles the XIth of Sweden and his whole army paſſed over it *, and the Adriatic was frozen in 1709 †. Hence, there is great reaſon to think, that within lat. 80°. N. and in much lower latitudes in the S. hemiſphere, the ſea is always frozen in winter. Upon the whole, the temperatures of land and water, in Winter, differ much more than in Summer, for in Winter, inland countries, from lat. 49 to 70 degrees, are frequently cooled down to 40, 50, and ſome to upwards of 70° below the freezing point; whereas the ſea below lat. 76° ſeems no where cooled below 4° under that point in our northern hemiſphere, except ſome narrow ſeas and ſome parts of the north Pacific Ocean; but in Summer no conſiderable extent of land is heated to more than 15 or 20 degrees above the temperature of the ſea, ſtony and ſandy deſarts excepted. All bodies require a certain quantity of elementary fire or light to heat them to a certain degree, but the quantity requiſite to produce this degree varies, according to the nature and ſpecies of theſe bodies, and hence the proportion ſuited to each, is called their *ſpecific* fire; the more of this any ſpecies of bodies requires, the greater time it will require, in the ſame circumſtances, either to acquire or to loſe it, that is, either to heat or to cool. Now water requires much more of it than earth, and therefore is longer either in heating or cooling; and therefore if the times of expoſure to the cauſes either of heat or of cold be the ſame, land will take more and water leſs of either of them; hence ice is firſt formed near the banks of rivers, or on the coaſts of the ſea, where the ſea is frozen.

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* Puffend. Hiſt. Europe. Mod. Un. Hiſt. in 8vo. Vol. 30, p. 180. † Mem Par. 1749.

Stones or *ſand* contain leſs ſpecific fire than earth, this being always moiſter, hence they heat and cool more readily, and to a greater degree, which accounts for the violent heats of the deſarts of Arabia and Africa, and the no leſs intenſe cold of Terra del Fuego, and other ſtony countries in cold latitudes. It is ſaid that caverns in gypſeous mountains are colder than thoſe in calcareous mountains *. Towns being formed of ſtone, or brick, are warmer in Summer than the open country, unleſs the ſtreets be ſo cloſe as to intercept the free action of the ſun's rays.

Living Vegetables alter their temperature very ſlowly and difficultly, but the evaporation from their numerous ſurfaces, is much greater, than from the ſame ſpace of land uncovered with vegetables; if they are tall, and cloſe as foreſts, they prevent the ſun's rays from reaching to, and warming the earth, beſides protecting the Winter's ſnow for ſeveral months. Hence wooded countries are much colder than thoſe that are open and cultivated; the difference is no where ſo ſtrongly marked as in Guyana; part of this country has been cleared from wood, only ſince the beginning of this century, and the heat in that part is already exceſſive; whereas in the wooded parts, the inhabitants are obliged to light a fire every night †, which ſhews that the earth retains very little heat. When dry, cold winds, ſuch as thoſe that blow over mountains, or dry, barren lands, paſs over foreſts, by exciting a more copious evaporation, they cool them, and are themſelves cooled by them, to a far greater degree than where that circumſtance does not occur, and hence the ſouthern countries of Europe are far warmer now, than they were 1700 years ago; for though Italy, for inſtance, might have been as well cultivated then as at preſent, yet, as Dr. Williamſon well remarked, Germany was covered with woods, and conſequently the winds that paſſed from it to Italy were far colder *. Abſtracting from the circumſtances to be mentioned in the next chapter, land takes 8 or 10 degrees more heat than the ſea in Summer, and is 8 or 10 degrees colder in Winter, in the ſame latitude.

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* 4 Decouvertes Ruſſes, p. 34. † 9 Buffon. Suppl. in 8vo. p. 346.

CHAP. V.

Of the Modifications of the Standard Temperature, on Land, ariſing from Situation.

WE have already ſeen that the higher regions of the atmoſphere are the coldeſt; that land is colder in Winter, and warmer in Summer than water; and that with reſpect to temperature, the covering of the ſurface of land, whether with vegetables, or with ſtone or ſand, is not indifferent; from whence it naturally follows, that the circumſtances that govern the temperature of land are, 1ſt. Elevation. 2dly. Vicinity to, or diſtance from, large tracts of water, particularly from the ſtandard ocean, as its influence is moſt extenſive, and as it is to its temperature that the temperature of all countries is to be referred, in moſt caſes. 3dly. The vicinity, or diſtance of other tracts of land, which by their elevation or the circumſtances of their ſurface, have a temperature peculiar to them, as ſtony, ſandy, and wooded countries. 4thly. The bearing of neighbouring ſeas, mountains, foreſts, deſarts, &c. 5thly. A more or leſs perfect communication with the ſtandard ocean, ſeas, foreſts, &c.

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* Mem. Philad.

§ 1.

Of Elevation.

AS heat is propagated through the atmoſphere, chiefly by contact and communication with the earth, it is evident that lofty mountains, particularly if their horizontal ſurface be not very extenſive, cannot warm it to any conſiderable degree, as they themſelves receiving the ſun's meridian rays more obliquely, and communicating leſs with the common maſs of the earth, are leſs heated than plains, hence the ſteepeſt mountains are always the coldeſt; but elevated countries of large extent,

tent, ſuch as the interior parts of continents, and iſlands whoſe declivity is inſenſible, participate much leſs of this diminution of temperature; yet that part of the atmoſphere which is in contact even with the loftieſt mountains, is warmer, at leaſt in Winter, than air of the ſame height over plains, becauſe ſuch immenſe maſſes of earth, and ſtone, generally contain more heat than mere air, and the air in contact with them, being on that account ſpecifically lighter than the more diſtant air, this of courſe moves towards the mountains, or the general current of the atmoſphere flows towards them with greater velocity, and hence clouds ſeem to be attracted by them, and winds are generally more violent on high mountains than on plains *. The air thus accumulated on their ſides, is at length forced over their ſummits, but in aſcending to a greater height than that, at which it was impregnated with vapour, it is cooled and conſequently depoſits this vapour, which thus forms miſts on the ſides of the mountain, and when the quantity of vapour thus condenſed is conſiderable, it warms the air to a conſiderable degree †. On the other hand, the air forced over the mountain, being deprived of its vapour, and falling on the neighbouring plains, greedily abſorbs the moiſture it had loſt, and thus pro-

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* De Luc. † See a full and excellent account of theſe phænomena, by Mr. Du Carla, 21 Roz. and the ſucceeding volumes.

duces a conſiderable degree of cold. Thus a N. W. wind blowing on the mountains of Norway occaſions a thaw, but when it has paſſed theſe mountains and entered Sweden, it produces the moſt intenſe cold *; and for the ſame reaſon, this wind is obſerved to be the drieſt and coldeſt on the eaſtern coaſt of Scotland, and the heavieſt rains come from the Eaſt and S. E. †.

With reſpect to the preciſe effect of elevation, I find it to be very nearly as follows.

1ſt. When the elevation is moderate and gradual, ſuch as that of the interior parts of moſt countries very diſtant from the ſea, its effects are ſo blended with thoſe of diſtance from the ſtandard ocean, to be mentioned in the next ſection, that the ſame allowance in the diminution of temperature, is to be made for both. By a gradual elevation, I mean any that riſes at a leſs rate than ſix feet per mile, counting from the neareſt conſiderable ſea.

2dly. If the elevation proceeds at a greater rate, then for every 200 feet of elevation, we muſt diminiſh the annual temperature of the ſtandard in that latitude, as follows.

If the elevation be at the rate of

6 feet per mile	-	$\frac{1}{4}$ of a degree.
7 feet	- -	$\frac{1}{3}$
13 feet	- - -	$\frac{4}{10}$
15 or upwards	-	$\frac{1}{2}$

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* Mem. Stock. 1757.

† 3 Ed. Eſſays, p. 12.

To find the height of any place, I compare the mean annual height of the barometer at that place, at its mean annual temperature, with its mean height at the level of the neareſt ſea at the mean annual temperature of that ſea, which height I ſuppoſe to be 30 inches. Sir George Schuckburgh found it ſo in the Mediterranean and channel, in the temperature of 55 and 60°. Mr. Bouguer found it ſo on the coaſt of Peru, in the temperature of 84°; and Lord Mulgrave obſerved it at the ſame height in lat. 80°: and though ſome ſeas are ſaid to be higher than others, yet this inequality is never ſo great as to occaſion any important difference in the height of the barometer.

§ 2.

Diſtance from the Standard Ocean.

FROM the frequent intercourſe of land and ſea winds, the annual temperature of countries bordering on the ocean, differs very little from that of the ſtandard in the ſame latitude, unleſs their elevation, or ſome of the circumſtances already mentioned occaſion a difference; for though they are ſomewhat warmer in Summer and colder in Winter, yet upon the whole within the year, theſe differences nearly balance each other in the temperate latitudes; but at the diſtance of 50 miles from the ſea, and ſtill more at greater diſtances, the differences ariſing from the unequal capacities of land and water are ſenſibly perceived, the mean annual temperature in different latitudes being depreſſed or raiſed in every 50 miles diſtance, nearly at the following rate:

From lat. 70° to lat. 35° cooled $\frac{1}{3}$ of a degree.
35° - - $\frac{1}{8}$
30° - - 0
25° warmed - $\frac{1}{5}$
20° - - $\frac{1}{2}$
10° - - 1°

It appears then, that from lat. 70° to lat. 30°, elevation, and diſtance, conſpire in producing the ſame effect, that is, in lowering the annual temperature; hence one would ſuppoſe, that their joint effect ſhould be the product of both powers; but as the effect of elevation is in ſome meaſure complicated with that diſtance, namely, when the elevation is leſs than 6 feet per mile, I find it more agreeable to obſervation, to *add* the effects of diſtance and elevation to each other.—In latitudes below 30°, elevation and diſtance from the ſtandard ocean, in general counteract each other, and therefore the effect of one, is to be ſubtracted from that of the other.

§ 3. *Of*

§ 3.

Of the Modifications produced by the Vicinity and Bearings of Mountains, Seas, &c.

ALL countries lying to the windward of high mountains, or extenſive foreſts, are warmer than thoſe lying to the leeward, in the ſame latitude.

Countries that lie ſouthward of any ſea, are warmer than thoſe that have that ſea to the ſouth of them, at leaſt in our hemiſphere, becauſe the winds that ſhould cool them in Winter are tempered by paſſing to them from that ſea; whereas thoſe that are northward of the ſea are cooled in Summer by the breezes that iſſue from it; but a northern or ſouthern bearing of the ſea, renders a country warmer, than if it lay either to the eaſt, or to the weſt.

Iſlands being ſurrounded by the ſea, participate more of its temperature, and are therefore warmer than continents; moſt great iſlands have, (which is very remarkable) their greateſt extent, from north to ſouth, as Great Britain, Ireland, Madagaſcar, Ceylan, Formoſa, Sumatra, &c. yet in our hemiſphere, the ſouthern parts, are proportionably colder than the northern, becauſe the northerly winds in Winter are cooled, by blowing over a large extent of land *. A ridge of mountains generally traverſes them in the direction of their length.

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* Hence Pallas was much miſtaken in imagining, that England would be much colder, if it were not ſheltered from the northerly winds, by the mountains of Scotland.

CHAP. VI.

Of the Temperature of the North Pacific Ocean, from Lat. 66° to 52°.

THIS part of the Pacific Ocean, is contracted in lat. 66° to the narrow ſpace of 40 miles, and in lat. 52° it occupies the ſpace of only 30° in breadth, from eaſt to weſt, that is about 1300 miles*; whereas the Atlantic in lat. 52° is about 1700 miles in breadth, and is no where contracted to a leſs ſpace than 700 miles. Add to this, that the coaſt of Aſia on the one ſide, and thoſe of America on the other, are bordered with high mountains covered with ſnow for a great part of the year; and numerous high iſlands lie ſcattered between both continents. From theſe circumſtances we have ſufficient reaſon to conclude *a priori*, that this ſea ſhould be much colder than that portion of the Atlantic, contained between the ſame parallels; for, during the Winter, the mountains that line the coaſts, are cooled to a much greater degree, than the flat coaſts of the Atlantic; and the ſea, where narrow, is intirely frozen; in Summer, heaps of ice being long ſheltered from the ſun by the iſlands, are carried down into lower latitudes, and the ſnow remains long unmelted on the mountains; ſo that I am inclined to think, that the annual temperature of it, is at leaſt, 4 degrees below that of the ſtandard in each correſponding latitude. But the obſervations either on theſe ſeas, or the neighbouring coaſts, are not as yet ſufficiently numerous, to determine with any preciſion, the mean annual temperature of theſe parts. The few particulars here mentioned, are chiefly collected from the account of Captain Cook's laſt Voyage; but the zeal of that beſt and greateſt of Sovereigns, the preſent Empreſs of Ruſſia, whoſe love of ſcience, and of every improvement that can contribute to the happineſs of mankind, can only be compared with the extent of her empire, will not, it is to be expected, long ſuffer the meteorological hiſtory of ſo conſiderable a part of the globe to remain unknown.

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* The degrees of longitude are computed from a table in Mr. De La Lande's Aſtronomy. Toiſes divided by 825, give Engliſh miles, very nearly.

CHAP. VII.

Of the Temperature of the Eaſtern Part of North America.

THERE are many circumſtances that contribute to render theſe parts colder than the oppoſite parts of the old continent.

Firſt, The higheſt lands in North America are contained between the 40th and 50th degrees of latitude, extending from north to ſouth between the 100th and 110th degrees of longitude weſt of London; here the greateſt rivers have their ſource. To the eaſt of theſe lie the Lakes Superior, Michegan, Huron, Oſwego, &c. and the intermediate country is covered with impenetrable foreſts; hence, this vaſt ſpace is incapable of receiving much heat in Summer, and conſequently one great ſource of that warmth, by which the Winters in the old continent are moderated, is here conſiderably diminiſhed; add to this, the ſwamps and moraſſes, which are equally incapable of receiving any conſiderable heat; hence, the weſterly winds, at leaſt ſuch of them as originate behind theſe high lands, having depoſited their vapours in paſſing over them, re-abſorb them from theſe immenſe foreſts and numerous lakes, and thereby are cooled ſtill more. Farther north, namely, between lat. 52° and 63°, lie Hudſon's Bay and Streights; about 50 miles on the ſouth of this Bay, from lat. 50° to 58°, there runs a ridge of mountains, which prevents its receiving any heat from that quarter, and hence the intermediate country is ſo cold that ſcarce any animal can live in it *. To the eaſt, this bay is bounded by the barren, mountainous country of Labrador, and a number of iſlands that lie at its entrance. The portion of the Atlantic oppoſite to the entrance of the Streights, is ſurrounded, partly by the continent of America, and partly by Greenland, as far down as lat. 59°; both are mountainous and interſected by a multitude of creeks and inlets, which are frozen over in Winter, and in the enſuing Summer the floating ice is protected by numerous high iſlands, and partly carried down the eaſtern coaſt of America, ſometimes as far as latitude 42 †, cooling the atmoſphere far below the ſtandard.

Hence, the N. W. winds are the coldeſt in all theſe parts of America, and by the meteorological journals that have been publiſhed, the annual temperature ſeems to be about 10 or 12 degrees lower than the ſtandard.

But, as the cultivated parts of America are at preſent much more temperate than they were a century ago, it may be preſumed, that

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* Carver's Travels, p. 108. † Hiſt. Accad. Par. 1725.

when the country is ſtill further cleared of woods, the climate will be ſtill further improved, though, from the ſituation of the high lands, I believe it will never be ſo moderate as that of Europe.

CHAP. VIII.

Of the Temperature of the Southern Hemiſphere.

FROM the equator to latitude 40°, the temperature of this hemiſphere ſeems to be exactly the ſame as that of the correſponding parallels on the northern ſide*: but it is the general opinion, that the more ſouthern latitudes are much colder than the northern, equally diſtant from the equator. If this opinion reſpected only the Summer ſeaſon, or latitudes higher than 60°, there is good reaſon to think it well founded; for, in this hemiſphere ſo low as lat. 68°, the ſea has been found, by that incomparable navigator Captain Cook, every where frozen; and large maſſes of ice are in Summer detached and carried down as low as lat. 50°, or even 46°, and there, melting, diffuſe cold to a far greater extent: but on the other hand, the abſence of land, which is known to receive a far greater degree of cold than water, makes it highly probable, that the antarctic Winters are much milder than the arctic, at leaſt on land.

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* 1 Gentil. Voy. p. 73.

It is worthy of obſervation, that Dr. Halley and Mr. Wales have ſometimes found the northern wind colder than the ſouthern, in this hemiſphere *.

CHAP. IX.

Of the Temperature of the Leſſer Seas.

IN general theſe ſeas, if not ſurrounded by high mountains, are a few degrees warmer in Summer, though colder in Winter, than the ſtandard ocean; in high latitudes they are frequently frozen.

White Sea.

This ſea is frozen in Winter †

Gulph of Bothnia.

It is in great meaſure frozen in Winter ‡, but in Summer it is ſometimes heated to 70°, a degree of heat never to be found in the oppoſite part of the Atlantic *; its general temperature in July is from 48 to 56.

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* Dalrymple's Voy. p. 37, and Wales's Obſervations on his Voyage.

† 2 Dantzic Abhandl. p. 143.

‡ Mem. Stock. 1757.

German Sea.

This ſea ſeems to be about 3 degrees colder in Winter, and 5 degrees warmer in Summer, than the Atlantic; hence, though colder in Winter, yet it is as warm in Summer at Southwic, lat. 52° 31′ ‖, as at Briſtol, lat. 51° 33′: the annual temperature is even lower at Briſtol than at London; thus in 1778, the temperature of London was 53,1, but that of Briſtol was only 52.

Mediterranean.

This ſea is for the greater part of its extent, warmer, both Summer and Winter, than the Atlantic, which for that reaſon flows into it; but the Adriatic, though warmer in Summer, is ſo cold in Winter, as to have been frequently frozen over ‡ in the neighbourhood of Venice.

Black Sea.

Is colder than the Mediterranean, and flows into it.

Caſpian.

This ſea is ſituated in the neighbourhood

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* Mem. Stock. 1776. ‖ 8 Phil. Tranſ. Abr. p. 610.

‡ Mem. Par. 1749.

of high mountains, and is in great meaſure frozen in Winter; its level is ſaid by Pallas to be lower than that of the ocean*.

CHAP. X.

Of the Temperature of Places lying between the 81ſt and 55th Degrees of Northern Latitude.

Lat. 80.

ON the 28th of June, O. S. An. 1758, at Sea, Mr. Rowlandſon Martin found the temperature of the air, during the whole 24 hours, betwixt 46 and 47 degrees; the preceding and ſucceeding days were much colder, but he was informed that the Summers were often warmer ‡. In lat. 79°50′, Lord Mulgrave obſerved the greateſt heat for two days to be 58° and the leaſt 46†. Theſe obſervations agree well with my table. Mr. Martin obſerves, that the weather in the polar regions is very unſteady; one hour it blows a violent ſtorm, and in the next, there is a dead calm; neither does it blow long in any one point, but ſometimes from every point, within the period of 24 hours. After a calm, the north wind ſprings up firſt; the ſky is ſeldom perfectly clear, and ſtorms are much more frequent than in lower latitudes.

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* 3 Decouvertes Ruſſes, p. 90. ‡ Mem. Stock. 1758.
† Mem. Par. 1774.

On the 16th of May, lat. 78° 30′, the temperature of the air being 16°, the ſea was frozen, but ſea-water in hogſheads was frozen in the temperature of 28°, which agrees with Mr. Nairne's experiments. It is remarkable, that in lat. 80°, long. 0, Lord Mulgrave found the temperature of the air 44°, wind E. N. E. and Mr. Duhamel, the ſame day, in Gatinois, lat. 48°, long. 1°, found the wind alſo N. E. and its temperature 71°.

Spitſbergen conſiſts of a cluſter of mountains, formed of a ſort of ſlate: Lord Mulgrave meaſured one of them, and found it 1503 feet high; the ſnow which almoſt always covers theſe mountains, renders the neighbourhood of Spitſbergen colder than the open ſea. He met with ice for the firſt time, July the 4th, in lat. 79° 31′, but he ſays it is generally firſt found in lat. 73° or 74°.

Wadſo, in Lapland, lat. 70° 5′.

According to Mr. Hellant, the temperature of ſprings, and conſequently the annual temperature is 36°; by my table 37°,2. The difference ariſes from its height over the level of the ſea, which is probably conſiderable, as the mean height of the barometer for the ſix Summer months was about 29°,2.

It has been remarked, that the north ſide of the ridge of mountains, that extend betwixt Tornea and the North Sea, is not ſo cold as the ſouthern ſide of thoſe mountains, for the reaſon given p. 42, *.

Utſjoki, lat. 69° 52'.

An. 1758, on the 11th of April, it was ſtill Winter, the temperature in day-time being from 19 to 14°; from that to the end of the month it varied, being ſome days at 41°, and ſome at 50°, with a S. wind †.

On the ſecond of May, the thermometer was at 18° at 12 o'clock, but from the 5th to the 21ſt, it was generally at 38 or 40°; the ten laſt days were again cold.

In June it froze the three firſt nights, but from that time till the end of Auguſt, there was no more froſt; the warmeſt day in June was 61°; the nights were generally at 42°.

In July the heat once roſe to 77°, yet the Summer was reckoned unuſually cold; the wind was moſtly at north.

From the 1ſt to the 16th of Auguſt, the thermometer was by day from 46 to 61°, and at night from 37 to 45°; from that to the 19th, it was by day, from 64 to 66°; on the 27th, it froze at night.

During the twelve firſt days of September, the wind being conſtantly at ſouth, the wea-

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* 11 Collect. Acad. p. 211. † Mem. Stock. 1759.

ther was warm, being moſtly at 50°; then the wind turned to N. and the weather was colder, being at night 36°, and by day 46°; after the 21ſt, it froze every night, and in day-time was at 34°.

The twelve firſt days of October were moſtly at 32°; after which, the weather became much colder, though it thawed ſome days; on the 26th, the cold was below 0.

In November it thawed one day, but the mean temperature of the month was 15°. From the 23d, the ſun no longer appeared above the horizon, and yet on the 30th, the cold did not exceed 23°.

The firſt twenty days of December were exceeding cold, though a S. wind moſtly reigned, the cold being from 4 to 15° under 0; but what is very ſurpriſing, from the 22d to the end of the month, the weather was very mild *.

I have been thus prolix in relating the temperature of this country, as it is from hence that our ſtrong northerly winds blow; and we learn from it ſeveral curious particulars. 1ſt. We ſee that during the entire abſence of the ſun, the cold is not ſo great as might be expected; and theſe, I believe, are the only obſervations ever made in that intereſting circumſtance. 2dly. That when the countries ſouth of Lapland are frozen, the

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* Schwed. Abhand. 1759, p. 228.

ſouth winds are the coldeſt; for, during the laſt and warmeſt part of December, the wind was not ſouth, but moſt probably north; and then the cold was but a few degrees below congelation. 3dly. We ſee that in this higheſt of all inhabited latitudes, the cold is not near ſo great even when greateſt, as we ſhall ſoon ſee it to be in ſome countries, lying ſo low as lat. 52°; and hence we have great reaſon to think, that the cold of the pole is not ſo intenſe as is commonly imagined.

The barometer varied here from 27,8 to 30,4 inches.

Kola, lat. 68°52′, long. 30° E.

In the year 1769, the mean temperature during the following months, was

March	- -	27°
April	- -	35
May	- -	54,5
June	- -	44
July	- -	56

According to Mayer, it is 420 feet above the level of the ſea; the thermometer was once in May at 73° *. Lapland being mountainous, its temperature muſt differ much from that of the ſea; the temperature of June was evidently irregular.

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* 2 Bergm. Erde Klot. 14 N. Act. Petrop.

Ponoi, lat. 67°, long. 47.

In the year 1769, the mean temperature of the following months, was [*]

		Greateſt Cold.	Leaſt.
March	14°	—20°	28°6
April	23,8	13,44	24,12
May	29	9,5	46
June	38	28	74

This town lies on a river of the ſame name, near the White Sea; this ſea is generally frozen in Winter; and hence, and from the vicinity of the oppoſite land of Siberia, the eaſtern coaſt of Lapland is much colder than the weſtern, or even the northern.

One day in June, the thermometer ſtood at 74°; the N. W. wind, paſſing over the mountains, is the coldeſt, the S. W. the warmeſt.

Umba, lat. 66° 39′.

The ſame year, its temperature in the following months was [†]

		Greateſt Cold.	Leaſt.
March	21°,87	—10°,75	43°,25
April	31	11	46,5
May	37,7	18,5	56,4

Umba is alſo ſituated near the White Sea: theſe obſervations were made 247 feet above its level. The interior parts of Lapland being very mountainous, are exceſſive cold.

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[*] 14 N. Act. Petrop. [†] Ibid.

Abo, lat. 60° 27′, long. 22° 18′ E.

The reſult of twelve years obſervations, from 1750 to 1761, both included, gives the mean annual temperature 39°,55, or rather 40° *.

Jan.	19°58
Feb.	21,38
March	27,32
April	39
May	49,46
June	60,26
July	65,48
Auguſt	60,26
Sept.	50,72
Oct.	39,2
Nov.	21,29
Dec.	20,66

The greateſt cold in that period happened in Jan. 1760, the thermometer then being at —32°, but the greateſt cold uſually obſerved is —7°; the thermometer is generally 85 days below 32°.

The greateſt heat within that period took place in July, 1757; the thermometer ſtanding at 95°, but the greateſt uſual heat is 91° †.

The ſtandard heat of this latitude, is 44°, ſo that the difference between the temperature of Abo and the ſtandard temperature, is 4 degrees; but its diſtance from the Atlantic is 540 miles; and ſince, as above ſeen, a diſ-

tance

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* In reducing foreign thermometers to that of Fahr. as ſome fractions are neglected, there is always a difference of about ½ a degree, loſt in the totality.

† Schwed. Abhand. 1763.

tance of 50 miles from the ſtandard, lowers the annual temperature $\frac{1}{3}$ of a degree, the diſtance of 540 miles ſhould lower it 3,6 degrees.

Peterſburgh, lat. 59° 56′, long. 30° 24′ E.

The mean annual temperature of Peterſburgh, during 6 years, from 1762 to 1777, was 38°,8.

Jan.	10°
Feb.	16,46
March	23
April	34,5
May	50,2
June	59,3
July	66,8
Auguſt	61,7
Sept.	52,8
Octob.	40,5
Nov.	26,8
Decem.	23,4

The greateſt cold obſerved in Peterſburgh was that at which mercury freezes, viz. —39°; but the greateſt on a mean of ſeveral years is — 25°; the froſt generally begins in October, and laſts with little interruption until April. The thermometer is generally 145 days below 32°. 70 below 19°. 30 below 8°,10 below—4°, and 1 at—25°. The Winter of 1777 was the mildeſt long known; yet the thermometer ſtood 69 days below 32°. 26 below 19°, 7 below — 4°, and 1 at — 10°, all at noon.

The greateſt Summer heat, on a mean, is 79°, yet once it amounted to 94°.

The ſtandard temperature of the lat. of Peterſburgh is 44°,3, the difference then is 5°,5, which is chiefly owing to its diſtance from the ſtandard; this diſtance amounts to 25 degrees of longitude, which in this latitude make 870 miles, and, at the rate already mentioned, ſhould lower the temperature 5,8 degrees; the neighbourhood of the ſea moderates it ſomewhat.

It ſcarce ever hails at Peterſburgh *.

Upſal, lat. 59° 51′, long. 17° 47′ E.

From the year 1739 to 1757, the mean yearly temperature was 41,88 †.

Jan.	24°08
Feb.	25,16
March	29,12
April	38,6
May	47,84
June	59,54
July	62
Auguſt	59,72
Sept.	52,16
Octob.	42,36
Nov.	33,62
Decem.	27,32

The greateſt cold during that period ſeldom exceeded 5°, and only once reached — 25°.

The heat of Summer frequently reaches 80°. During the Summer of the year 1747, which was uncommonly warm, there were 61 days above 68°, 13 above 77°, and 4 between 82° and 86°.

It has been obſerved, that the ſame ſpecies of vegetables bud 31 days ſooner at Montpelier, and 28 days ſooner in London than in Upſal ‡.

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* 9 Vet. Com. Petrop. † Schwed. Abhand. 1753.
‡ 2 Bergm. Erde Klot.

The ſtandard temperature of the lat. of Upſal is 44°,3, the difference then is 2°,42; but Upſal is 360 miles from the Atlantic, therefore its annual mean ſhould be 2°,4 lower.

Stockholm, lat. 59° 20′. Long. 18, E.

The mean of 20 years obſervations, made at Stockholm, gives its annual temperature 42,39 *.

Jan.	22°68
Feb.	25,3
March	27,9
April	38,7
May	49
June	61
July	63,9
Auguſt	61,8
Sept.	53,2
Octob.	42,9
Nov.	34,5
Decem.	27,8

The greateſt cold is generally — 2°, ſcarce ever — 5°; however, it was once, namely in Jan. 1760, — 20°. The cold ſets in about the month of November, and laſts until the end of March.

The Summer heat reaches 75°, and not unfrequently 84°.

The difference of temperature of one year from another amounts to about 5 degrees; that is, ½ above, and 4°,5 below the mean above given.

Mr. Wargentin, in examining a ſeries of 39 years, could not find that any one year reſembled another; but he found that the Winters were formerly more ſevere than of late.

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* Mem. Stock, 1778.

The ſtandard temperature of the latitude of Stockholm is 44°,71, the difference then is 2°,32; its diſtance from the ſtandard is 432 miles, therefore it ſhould be 2°,8 colder.

Solyſkamſki, lat. 59°, long. 54, E.

The mean temperature of the year 1751, as far as I can collect from an imperfect account of it in the Philoſophical Tranſactions of the year 1753, was 32°,5.

Jan.	—2°
Feb.	8,6
March	42,8
April	42,8
May	49,4
June	62
July	58
Auguſt	50,8
Sept.	45
Octob.	27
Nov.	—3,4
Decem.	10,1

Solyſkamſki is ſituated on the borders of Siberia, weſt of the Ourals; as we have its temperature only for one year, we cannot expect it to agree with the rules laid down on this ſubject. However, we may remark, that as its diſtance from the ſtandard is 1332 miles, it ſhould be 8°,8 degrees colder, and therefore its temperature ſhould be 36°,2, which probably is nearly the truth.

Of the Temperature of Siberia and Kamſchatſka.

As the temperature of Siberia has ſome influence on that of lower latitudes, it will be proper to mention here ſome circumſtances that are peculiar to it.

Siberia is not only one of the moſt diſtant tracts of the old continent from the ſtandard ocean, but it is attended with another circumſtance, moſt unfavourable to its temperature; for it contains the moſt conſiderable elevation, not having the appearance of a mountain in the old continent. This elevation even paſſes the bounds of Siberia, for it extends from lat. 54° to 47°, and from long. 55° to 130°, eaſt of London; that is, 500 miles from north to ſouth, and 3315 from eaſt to weſt. It even runs ſtill further weſt, but with diminiſhed height. This height, as far as I can collect from various accounts, and barometrical obſervations, amounts to from 2500 to 3000 feet. Hence the N. E. winds proceeding from this country to Ruſſia, Poland, Germany, England, and France, muſt be much colder, in proportion to the latitude, than thoſe that blow on Sweden, or Scotland, and colder than the mere northerly winds, that come to us over a large tract of ſea.

I have no where met with a ſeries of obſervations taken in Siberia even for one year; but, it is certain, that not only in Yakutſk, lat. 62°, long. 130°, E. and Yeniſeiſk, lat. 58° 30′, long. 92°, E. Mercury has often been frozen by the natural cold, which conſequently reached, or exceeded — 39°*; but that the cold is nearly as great at Selengenki and Irkutz, lat. 52° 15′, long. 105°, E. The mean temperature of this laſt-mentioned place, from October 1780 to April 1781, both included, was — 6°,8; a degree of cold ſo great and durable, as I believe has no where elſe been obſerved in ſo low a latitude †.

Kamſchatſka is ſo diſtant from the Atlantic, that its temperature is no way influenced by it, but rather by that of the North Pacific to which it adjoins, and of which we have already treated. On the eaſtern coaſt, lat. 55°, Captain Cook found ſnow 6 or 8 feet deep in May, and it continued till June; in May the thermometer was moſtly at 32°, and on the 15th of June not higher than 58°; in Auguſt its greateſt height was 65°, and its loweſt 40°; in October the hills began to be covered with ſnow ‡; in November, December, and January, there are violent ſtorms accompanied with ſnow, the wind at E. and S. E.; in January

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* See Dr. Blagden's accurate Hiſtory of the Congelation of Mercury, Phil. Tranſ. 1783. † Mem. Peterſb. 1782. ‡ 3 Cooke's Voy. p. 328.

nuary the cold is ſometimes — 28°, but generally — 8[*].

The northern parts of this peninſula enjoy the moſt moderate weather, being chiefly influenced by the north ſea, whoſe temperature, I believe even in Winter, is milder than that of the ſea below the ſtreights, that ſeparate Aſia from America.

Churchill, or Prince of Wales's Fort, lat. 59°, long. 92°, W.

The temperature of 12 months, from September 1768, to the end of Auguſt 1769, was 24°,7; the mean of each being as follows[†]:

1769	January	28°
	February	20
	March	12
	April	20
	May	38
	June	50
	July	58
	Auguſt	50
1768	September	42
	October	28
	November	5
	December	18

Here the temperature is 20 degrees below the ſtandard, but the Winter of 1769, was rather ſevere, even in Europe. However, from the different temperature even of Summer, we may conclude that the weather is colder here than at Solyſkamſki.

In July the thermometer was one day at 85°.

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[*] Steller.

[†] Phil. Tranſ. 1770, p. 148, &c.

Nain in Labrador, lat. 57°.

From obſervations made here during the latter part of the year 1778, ſome part of the year 1780, and the whole of the year 1779, the mean ſeems to have been 30°,54, that of each month being

Jan.	—0,9°
Feb.	—3,5
March	7,5
April	27,9
May	36,2
June	42,6
July	50,2
Auguſt	51
Sept.	45
October	34
Novem.	26,5
Decem.	6,5

The temperature of the ſtandard is 46°,7, the difference then is 16,16; but it muſt be conſidered that the year 1779, was remarkably cold even in Europe.

The greateſt heat obſerved in the year 1780, was 84 degrees, and this was in July; the greateſt cold in 1779, was — 36 *.

The country of Labrador is exceeding barren, interſected with chains of lakes, deep bays, high craggy mountains, and unfruitful vallies: there is no appearance of Summer before July, though the Winters are ſaid to be leſs ſevere than formerly.

The ſea is covered with large bodies of ice that ſet in from the north, in Spring and Summer †.

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* Phil. Tranſ. 1781.

† Phil. Tranſ. 1774.

Edinburgh,

Edinburgh, lat. 55° 57, long. 3° W.

Theſe obſervations were made at Hawkhill, about 1 mile from Edinburgh, and 103 feet over the level of the ſea. They comprehend a mean of 3 years, from 1772 to 1774; this mean appears to be 47°,7 *.

Jan.	34°5
Feb.	36,6
March	41,7
April	46,3
May	50,4
June	57,5
July	60,6
Auguſt	60,6
Sept.	54,3
October	49,7
Novem.	41,1
Decem.	38,9

The temperature of the ſtandard is 47°,5, ſo that the difference is inconſiderable. Edinburgh is near the German ſea, which we have ſeen, to be upon the whole 2 degrees warmer than the ſtandard; but land, in this latitude, retaining ſnow, long after the degree of cold that produces it ceaſes, is always ſomewhat colder upon the whole, let the circumſtances be ever ſo favourable, than the ſea.

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* Phil. Tranſ. 1775, p. 462.

CHAP. XI.

Of the Temperature of Places, ſituated between the 55th and 40th Degrees of Latitude.

Franeker, lat. 53°, long. 5° 42′ E.

DURING five years, from 1777 to 1781, the mean temperature of this town was 52°,6. The monthly, as follows:

Jan.	32°72
Feb.	38,47
March	44,64
April	50,17
May	59,40
June	64,71
July	68,80
Auguſt	69,03
Sept.	62,91
Octob.	55,04
Nov.	45,54
Dec.	39,82

The greateſt uſual cold is 12°, the greateſt heat 82°.

The ſtandard temperature of this latitude is 50°,2, the difference is 2°,4; the reaſon of which is, that all continents, if flat, are in Summer much warmer than the ſtandard, and particularly thoſe which border on the German ſea, as that ſea is, upon an average of the whole year, 2 degrees warmer than the Atlantic; but in Winter, the German ſea is colder than the ſtandard, and Holland, in general, is much expoſed to N. E. Siberian winds.

Berlin, lat. 52° 32′, long. 13° 31′ E.

According to Mr. Beguelin's obſervations, the annual average temperature of Berlin, for 15 years, (from 1769 to 1782) was 49°, and after an attentive examination, he could not find that the temperature diminiſhes*.

Upon inſpecting obſervations of 8 years, I find the thermometer is generally 50 days below 32°.

The ſtandard temperature of this latitude is 50°,8, the difference is 1°, 8; as its diſtance from the ſtandard is about 840 miles, it ſhould be cooled 5,4 degrees, were it not for the intervention of the German ſea, which being 2 degrees warmer than the ſtandard, obviates in ſome meaſure, the effects of its diſtance from the ſtandard. But as this ſea is 240 miles diſtant from it, inſtead of 2 degrees, it gains but 1°,6 from it, which ſhould ſtill leave it 3°,8 colder than the ſtandard: but again, it has the Baltic within 120 miles on the north of it, which tempers the north winds, and leaves it the moderate temperature which it enjoys.

The influence of the neighbourhood of the Baltic muſt be allowed, when it is conſidered, that the temperature of Berlin is higher than that of Dreſden, Altenburgh, or Gotha, whoſe latitude is one degree lower, but more diſtant from the Baltic.

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* Mem. Berl. 1782.

Lyndon in Rutland, lat. 52° 30′, long. 0 3′ W.

The mean annual temperature of Lyndon during 15 years, (from 1771 to 1785) communicated to me by that aſſiduous and accurate obſerver, Mr. Thomas Barker, is 48°,03, that of the ſtandard 50°,6, the difference 2°,6. But the mean height of the barometer is but 29,4 inches, which, as the temperature of the neareſt ſea is 52°,6, gives an elevation of 540 feet nearly. This ſea is but 40 miles diſtant, therefore this elevation, according to the principles laid down in the 2d ſection of the 5th chapter, ſhould cauſe a diminution of 1°,4 of a degree. Beſides, Lyndon is 150 miles from the Iriſh ſea, the neareſt branch of the Atlantic, which diminiſhes the temperature 1 degree more: the remaining diminution is owing to its neighbourhood to the Engliſh Apennine, by which the weſterly winds are ſtill further cooled.

Leyden, lat. 52° 10′, long. 4° 32′ E.

Leyden is nearly in the ſame circumſtances as Franeker, but being farther from the German ſea, its temperature exceeds the ſtandard only 1,35 degrees.

London,

London, lat. 51° 31′.

From a mean of the obſervations made at the houſe of the Royal Society, from the year 1772 to the year 1780, it appears that the annual temperature of London is 51°,9, or in round numbers 52°; the monthly temperature as follows:

Jan.	35°9
Feb.	42,3
March	46,4
April	49,9
May	56,61
June	63,22
July	66,3
Auguſt	65,85
Sept.	59,63
Octob.	52,81
Nov.	44,44
Dec.	41,04

The greateſt uſual cold is 20°, and happens in January; the greateſt uſual heat is 81°, and happens generally in July.

The limits of the annual variation are 2,5 degrees, that is, one degree above and 1°,5 below the mean.

The greateſt variations of the mean temperature of the ſame month in different years, are as follows:

Jan.	6°	May	2°,5	Sept.	3°,5
Feb.	5	June	2	Oct.	4
March	4	July	2	Nov.	4
April	3	Aug.	2	Dec.	3

Hence we ſee that the Summers differ much leſs than the Winters.

The moſt uſual variations of temperature within the ſpace of 24 hours in every month, are

Jan.	6°	May	14°	Sept.	18°
Feb.	8	June	12	Oct.	14
March	20	July	10	Nov.	9
April	18	Aug.	15	Dec.	6

Thence the origin of vernal and autumnal colds.

The mean height of the lower term of congelation is moſt probably in

	Feet		Feet		Feet
Jan.	1800	May	7369	Sept.	8268
Feb.	3084	June	9480	Oct.	6240
March	4314	July	10380	Nov.	3715
April	5400	Aug.	10126	Dec.	2770

The lower term of congelation is to the upper, nearly as 10 to 18.

The ſtandard temperature of the latitude of London is alſo 52°; for though it ſhould be cooled 1°,2, by reaſon of its diſtance from the ſtandard, yet it ſhould be heated nearly as much by its proximity to the German ſea. However, proportionably to its latitude, it is much colder in Winter at London than at Edinburgh; for we have ſeen the mean temperature of Edinburgh in January to be 34°,5, and that of London is 35°,9; the reaſons of which are, 1ſt. That Edinburgh is not expoſed to the Siberian winds, as London is. 2dly. That Edinburgh is nearer to the ſea. 3dly. Becauſe the rigour of the northerly winds is very little moderated, if not increaſed, in paſſing from Scotland to us, particularly if the ſurface of the earth is covered with ſnow; and hence, if we may believe Dr. Smollett *, the Winters are ſometimes milder at Edinburgh, than at London.

Dunkirk, lat. 51° 02′, long. 2° 7′ E.

The temperature of Dunkirk, on a mean of ten years, as given by Pere La Cotte, was 54° 9′ †.

Jan.	41°
Feb.	44
March	46
April	53
May	60
June	65
July	68
Auguſt	68
Sept.	64,6
Oct.	53,4
Nov.	46,5
Dec.	40

The temperature of the ſtandard latitude is 52° 4′, the difference is 2° 5′; this proceeds from its vicinity to the German ſea, which, as has already been often noticed, is upon the whole, two degrees warmer than the Atlantic; beſides, the Britiſh channel, which is at no great diſtance on the S. Weſt, tends much to render its temperature milder.

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* Travels to Italy.

† Meteorolog. de La Cotte, p. 360.

Manheim, lat. 49° 27′, long. 9° 2′ E.

The temperature of this capital of meteorology, during the years 1781 and 1782, was 51° 5′.

Jan.	35°08
Feb.	35,8
March	43,9
April	52,6
May	58,2
June	68,7
July	70,9
Auguſt	66,2
Sept.	62,3
Oct.	38,5
Nov.	48,08
Dec.	35,6

The ſtandard temperature is 52° 6′. Its diſtance from the Britiſh channel is about 200 miles, and from the German ſea ſomewhat leſs; ſo that its temperature ſhould be nearly one degree below the ſtandard.

Rouen, lat. 49° 26′, long. 1° W.

The mean of the years 1779 and 1780 was 50° 7′, but it muſt be remarked, that the Winter of 1779 was uncommonly cold *.

Jan.	28°96
Feb.	36,83
March	45,99
April	49,88

The ſtandard temperature is 52° 6′, to which the real temperature of Rouen ſhould approach conſiderably, as its diſtance from

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* Mem. Societ. Med. Paris.

the channel is inconſiderable; hence it is probable, that December, January, and February, are 3 degrees below the uſual mean of theſe months.

May	60°57
June	62,48
July	65,41
Auguſt	68,11
Sept.	62,43
Oct.	53,82
Nov.	38,86
Dec.	34,70

Ratiſbon, lat. 48° 56′, long. 12° 05′ E.

The mean of the years 1781 and 1782 was 49°,35.

Jan.	30°52
Feb.	30,76
March	40,21
April	50,22
May	59,87
June	68,52
July	70,4
Auguſt	68,22
Sept.	61,68
Oct.	45,49
Nov.	35,22
Dec.	31,14

The ſtandard of this latitude is 53°,8, the elevation of Ratiſbon is conſiderable, as the mean height of the barometer during thoſe years was 28,88, but with reſpect to its diſtance from the neareſt ſea, this elevation is inconſiderable; its diſtance from the ſtandard, is 580 miles, which ſhould lower its temperature 2°,32. Its true temperature is probably on that account 51°,48.

Paris, lat. 48° 50. long. 2° 25′ E.

The temperature of this celebrated city, deduced from a ſeries of obſervations, uninterruptedly continued for 71 years; that is, from 1699 to 1770, was 51°,97; or in round numbers 52°[*]; the monthly as follows.

Jan.	34°5
Feb.	39
March	43,25
April	51,2
May	59,2
June	66
July	68,75
Auguſt	68
Sept.	63,5
Oct.	52
Nov.	42
Dec.	36,8

The greateſt heat during that period happened in the year 1720, amounting to 104°; the greateſt cold was obſerved in the year 1709, the thermometer being at —1°; but a ſtill greater was felt in the year 1776, namely —4,5.

The ſtandard temperature of this latitude is 53°,9. Paris then, by theſe obſervations, is 1,9 degrees colder than its ſtandard; its diſtance from the wideſt part of the Britiſh channel, oppoſite to Coutances, in Normandy, is 154 miles, which ſhould diminiſh its temperature one degree: other parts of the channel are nearer, but perhaps too narrow to have any influence at a conſiderable diſtance; but I am inclined to think, that the old obſervations were faulty, and that its true temperature is at leaſt 53°, if not more; for that of the cave of the Obſervatory, is 53°,5 [†]; and if we conſider, that beſides the vicinity of the Atlantic on the weſt, the northerly winds paſs over a comparatively ſmall tract of land, before they arrive at it, we ſhall ſee reaſon to think, that its temperature cannot be one degree below that of the ſtandard.

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[*] Meteorol. de La Cotte. [†] Van Swind. Therm. p. 82.

Troyes, lat. 48° 18′, long. 4° 10′ E.

During the years 1779, 80, and 81; the mean heat of this capital of Champagne, was 53°,17 *.

Jan.	33°12
Feb.	39,49
March	48,04
April	53,97
May	59,37
June	65,14
July	68,44
Auguſt	70,32
Sept.	63,34
Oct.	54,27
Nov.	43,70
Dec.	38,89

The ſtandard temperature is 54°,4; the difference 1°,43; its diſtance from the Atlantic is 280 miles, by which it ſhould be cooled 1°,8; perhaps the ſoil contributes to make it ſomewhat warmer.

Vienna, lat. 48°,12′, long. 16° 22′ E.

Its temperature, upon an average of the years 1779, and 1780, was 51°,34 †.

Jan.	27°5
Feb.	33,23

The ſtandard temperature is 54°,6; the difference 3°,26; but

the

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* Mem. Societ. Med. Par. † Ibid.

March	46°28
April	53,37
May	63,38
June	64,85
July	68,56
Auguſt	68,78
Sept.	61,36
Oct.	52,81
Nov.	40,99
Dec.	34,98

the diſtance of Vienna from the ſtandard, is 770 miles, which ſhould lower its temperature five degrees.

Dijon, lat. 47° 19′, long. 4° 57′ E.

By obſervations of four years, ending in 1781, the temperature of this town is 52°,8 *.

Jan.	33°06
Feb.	37,43
March	47,86
April	52,52
May	60,96
June	65,69
July	69,4
Auguſt	71,03
Sept.	62,48
Oct.	52,86
Nov.	43,41
Dec.	36,72

The ſtandard temperature is 55°,3; the difference 2,5; but the diſtance of Dijon, from the ſtandard, is 260 miles, which gives a diminution of 1,7 degrees. It is cooled ſomewhat further, by a ridge of mountains to the weſt of it, and the chain of Jura, about 60 miles to the eaſt.

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* Mem. Societ. Med. Par.

Nantes,

Nantes, lat. 47° 13′, long. 1° 28′ E.

This city being little diſtant from the ſtandard, it may be expected that its temperature ſhould ſcarce differ from it; and in effect, by four years obſervations, it amounts to 55,53 degrees, and that of the ſtandard is 55°,5 *.

Jan.	37°75
Feb.	42,25
March	50,17
April	54,76
May	60,85
June	65,29
July	69,61
Auguſt	72,04
Sept.	65,25
Oct.	56,25
Nov.	48,87
Dec.	42,34

Poictiers, lat. 46° 39′, long. 0° 30′ E.

From obſervations of five years, that is, from 1777 to 1781 incluſively, the temperature of this city ſhould be 53°,8.

Jan.	34°74
Feb.	40,27
March	48,96
April	52,74
May	58,90

But the ſtandard temperature is 55°,9; the difference 2,1, which is too great; for the Atlantic is but 70 miles diſtant, which ſhould occaſion a dimi-

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* Mem. Societ. Med. Par.

June	64°08
July	69,48
Auguſt	70,86
Sept.	63,40
Oct.	54,54
Nov.	46,35
Dec.	40,27

nution of only ½ a degree, if the intervening woods do not increaſe the effect of diſtance.

Lauſanne, lat. 46° 31′, long. 6° 50′ E.

The temperature of this town, deduced from obſervations for ten years, by that intelligent and accurate obſerver Dr. Verdeil, was 48°,87*.

Jan.	28°6
Feb.	36,4
March	40,3
April	48,2
May	56,7
June	64,6
July	65,7
Auguſt	66,6
Sept.	59,7
Oct.	49,5
Nov.	40,1
Dec.	33,8

The ſtandard temperature is 56°; the difference is 7°,13; but the diſtance of Lauſanne from the Atlantic is 388 miles; this produces a diminution of 2,58 degrees in its annual temperature. Its elevation over the neareſt ſea (the Mediterranean) is 1700 feet; its diſtance from this ſea 210 miles; this elevation exceeds the rate of 8 feet per mile, and therefore gives a diminution of $\frac{1}{3}$ of a degree on every 200 feet, which makes in all 2,43 degrees; which added to the diminution ariſing from diſtance, make the total diminution 5,01 degrees; the remaining two degrees muſt be attributed to the mountains in its vicinity, for on the weſt it has the range of Jura, which intercepts its communication with the ocean, and the warmer parts of France; on the ſouth, the mountains of the Pays de Vaud and Savoy, and to the eaſt, at no great diſtance, the frozen mountains of Swiſſerland.

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* 1 Mem. Lauſanne.

The greateſt heat obſerved during that period, was 87°, the greateſt cold 7°.

Aſtracan, lat. 46° 21′, long. 51° E.

Though I have not, as yet, met with a regular ſeries of obſervations, made in Aſtracan; yet, on account of the great difference of its temperature from that of all other places in Europe, ſituated under the ſame parallel; the few that have been made there, deſerve particular notice; and ſo much the more, as they confirm the theory, of the effects of diſtance from the ſea; the three firſt and laſt were made in 1780 *.

	Aſtracan.		Peterſburgh.
Jan.	16°,5	-	8°
Feb.	18,6	-	20
March	32	-	25
April	52		

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* Mem. Peterſb. 1782.

		Aſtracan.	Peterſburgh.
	[*] May	68°	
An. 1746	June	74	
	July	80	
	Auguſt	80	
	Sept.		
	Oct.	47	40°
	Nov.	38	22
	Dec.	15	17

The diſtance of Aſtracan from the neareſt part of the Atlantic, to wit, the Bay of Biſcay, is 2760 miles, which by the rule, chap. 5. § 1. ſhould cauſe a diminution of 11° in its temperature, and leave it 45°,4, which probably, is its true mean annual temperature. It is true the Caſpian is cloſe to it, and the Black Sea not half the diſtance of the Atlantic; but the Caſpian is itſelf in great meaſure frozen in Winter, as the Black Sea is ſaid to have often been, and its communication intercepted by mountains. Elevation certainly contributes nothing to the rigour of the Winter in Aſtracan, for the barometer is generally above 30 inches; but the ſandy deſarts in its neighbourhood probably contribute to the extraordinary heats it experiences.,

[*] Mem. Berl. 1746.

Montreal, lat. 45° 35′, long. 73° W.

It appears from a groſs eſtimate of the obſervations of Mr. Gaultier and Mr. Bar, both of which are too imperfect and confuſed to allow me to ſpecify their preciſe reſult, that the cold of Canada is as great, if not greater, than that of Aſtracan; but the Summer's heat is not near ſo great, nor does it laſt ſo long as at Aſtracan[*].

Padua, lat. 45° 23′, long. 12° E.

According to the obſervations of the celebrated meteorologiſt Mr. Toaldo, the mean temperature of this city during the years 1781 and 1782 was 52°,2.

Jan.	33°2
Feb.	34,7
March	45,2
April	55,3
May	58,4
June	71,9
July	76,5
Auguſt	75
Sept.	62
Octob.	51,9

The ſtandard temperature is 57°,2; the difference is 5°, but the diſtance of Padua from the Atlantic is 600 miles, by which it ſhould be cooled 4 degrees. In Winter it is ſtill further cooled by its vicinity to the Euganean mountains; and in Summer alſo, by the neighbourhood of the Adriatic: the Mediterranean is

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[*] Mem. Par. 1744, &c. See an ingenious Explanation of Gaultier's Thermometer, by Mr. Gauſſen of Montpelier, in 17 Roz. p. 39.

Nov.	41,2
Dec.	36,9

indeed much nearer to it than the ocean, but its influence is intercepted by the interpoſition of the Apennines; ſo that it's true temperature ſeems to be 52,6 or 52,8.

Rhodez in Guienne, lat. 45° 21′, long. 2° 39′ E.

Its temperature during the years 1779 and 1780 was 50°,94, or 51°; but as the Winter was uncommonly cold, this is probably much below the mean of common years.

Jan.	32°33
Feb.	36,72
March	45,21
April	48,20
May	59,78
June	62,14
July	64,96
Auguſt	70,36
Sept.	63,04
Octob.	50,
Nov.	40,32
Dec.	38,07

The ſtandard temperature is 57°,2, difference 6°,2; its diſtance from the ſtandard 150 miles, by which its temperature is lowered 1°; but the mean height of the barometer during theſe two years was 27,75 inches; and though I cannot, from this ſingle circumſtance, deduce the height with preciſion, as it is uncertain whether this be the true mean mercurial height; which ſeems on the contrary rather improbable, as the temperature of this period was colder than uſual, yet it may certainly be inferred, that the elevation of this place cannot be much leſs than 2000 feet, which muſt lower the temperature 3,3 degrees; and this depreſſion added to the former, gives 4,3 degrees, ſo that the real temperature may be 52,9 or 53 degrees.

Bourdeaux, lat. 44° 50', long. 0° 36' W.

Upon a mean of 5 years, (from 1777 to 1781) its temperature was 56°,8.

Jan.	38°88
Feb.	44,82
March	51,71
April	57,10
May	61,56
June	66,02
July	71,19
Auguſt	75,24
Sept.	61,15
Oct.	59,04
Nov.	49,68
Dec.	43,92

The ſtandard temperature is 57°,6, difference 0,8; this is chiefly owing to the uncommon cold of the 3 firſt months of the years 1777 and 1779, which were colder in proportion in the ſouth of France than elſewhere. In the year 1781, the mean heat was 58°,32, and in moſt of the other years 57°; ſo that the true temperature is very nearly that of the ſtandard.

Montpelier, lat. 43° 36' long. 3° 73' E.

Its temperature from 1777 to 1781 was 60°,87.

Jan.	42°21
Feb.	45,58
March	50,09
April	57,82
May	66,51
June	72,63
July	79,06
Auguſt	79,33
Sept.	71,64

The ſtandard temperature is 59°; Montpelier is then 1,87 degrees warmer. Its diſtance from the Atlantic is 260 miles, by which it ſhould be cooled 1,6 degrees; but its temperature is governed chiefly by that of the Mediterranean, which lying to the ſouth of it in ſtill

Oct.	63,22
Nov.	51,97
Dec.	46,48

warmer latitudes, communicates its temperature to it both Summer and Winter; but Winters, during which eaſterly winds from the mountains of Savoy and Piedmont prevail, muſt be much colder. The ſoil on which Montpelier ſtands, which is ſandy and ſtony, muſt contribute much to its heat.

Marſeilles, lat. 43° 19′, long. 5° 27′ E.

By obſervations of 34 years, namely, from 1745 to 1778, the temperature of this town was found to be 61°,8 *.

Jan.	45°9
Feb.	49
March	52,6
April	60,2
May	68,5
June	73,6
July	78,2
Auguſt	79
Sept.	71,2
Octob.	60,2
Novem.	53
Dec.	49

But the temperatures of the years 1780 and 1781, were much lower; the mean of theſe added to the foregoing is 61,7.

The ſtandard temperature is 59°,1; but like Montpelier the temperature here is influenced chiefly by the Mediterranean on which it borders; the ſoil alſo is ſandy and ſtony.

* Mem. Societ. Med. Par. 1778.

Mont Louis in Rouſſillon, lat. 42°, long. 2° 40′ E.

Mont Louis lies about 30 miles ſouth of Perpignan, among the Pyrenees, and is one of the higheſt inhabited parts of Europe. The mean height of the barometer being 24,65 inches, its temperature during the years 1780 and 1781, was 44°.

Jan.	27°93
Feb.	31,44
March	41,22
April	40,85
May	49,21
June	52,81
July	58,77
Aug.	58,32
Sept.	53,26
Octob.	44,82
Nov.	35
Dec.	33,9

The ſtandard temperature is 60°,3, the difference 16°,3; its diſtance from the Atlantic is 208 miles, by which it ſhould be cooled 1°,3 of a degree, but its height over the Mediterranean, from which it is about 40 miles diſtant, is 4500 feet. This elevation being above 15 feet per mile, cauſes a diminution of ½ a degree in every 200 feet, and conſequently in this caſe, of 11,25 degrees. Hence 12°,28 degrees are accounted for; by its ſituation among mountains covered with ſnow in Winter, and much loftier, it muſt be ſtill further cooled, though not, perhaps, as much as during theſe 2 years, which cannot be deemed to exhibit its true mean temperature.

Cambridge in New England, lat. 42° 25′, long. 71° W.

By a mean of the obſervations made here during the years 1781 and 1783, its temperature appears to be 50°,3, that is, about 10 degrees below the European ſtandard. The inequalities within each month are another peculiarity of the American climates, which I ſhall here exhibit.

	Mean	Greateſt Heat	Leaſt
Jan.	29°5	48°,5	0
Feb.	37,5	55	0
March	36,5	59	13
April	48,5	77	35
May	58,5	77	41
June	68,5	85	50
July	73	91	62
Aug.	71	92	62
Sept.	63,5	85	45
Octob.	50,5	68	38
Nov.	36	57	19
Dec.	31	61	12*

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* American Tranſactions, Vol. 1. p. 334.

Ipſwich

Ipſwich in New England, lat. 42° 38′, long. 70° 45′.

The mean temperature of the years 1781, 1782, and 1783, was 50°,17.

	Mean		Higheſt		Loweſt
Jan.	30°	-	49°	-	6°
Feb.	30	-	53	-	1
March	38	-	56	-	16
April	48	-	80	-	37
May	56,5	-	78	-	45
June	68	-	88	-	51
July	70,5	-	89	-	60
Aug.	70	-	88	-	55
Sept.	63,5	-	86	-	45
Octob.	51,6	-	72	-	40
Nov.	39	-	55	-	22
Dec.	37	-	55	-	14*

But it muſt be remarked that the thermometer was not perfectly expoſed to the air. In Jan. 1783, a thermometer without doors ſtood at 10° below 0; this Winter was here alſo uncommonly ſevere.

On the coaſt of America the eaſt winds are the cooleſt in Summer, and the warmeſt in Winter, as might be expected, they paſſing from the ſea.

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* 1 Amer. Accad. p. 349.

Apalachian or Blue Mountains, between New York and Albany, lat. 42°.

Mr. Kalm, in the month of July, when the external heat was 64°, found the temperature of a deep well 49°; that is 11° below the European ſtandard*.

Madrid, lat. 40° 25′ long. 3° 20′ E.

The uſual heat in Summer is ſaid to be from 75 to 85°; even at night it ſeldom falls below 70°; the mean height of the barometer is 27,96. It ſeems to be about 1900 feet above the level of the ſea †.

C H A P. XII.

Of the Temperature of Places, ſituated between Lat. 40 and Lat. 0.

Philadelphia, lat. 39° 56′, long. 75° 09′ W.

THE temperature of the deepeſt wells near this city was found to be 52°,5, that is, about 10° below the European ſtandard ‡.

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* Mem. Stock. 1771. † Mem. Par. 1777, p. 146.

‡ Mem. Stock. 1771.

Pekin, lat. 39° 54′, long. 116° 29′ W.

By 5 years obſervations its annual mean temperature was found to be 55°,5.

Jan.	20°,75
Feb.	32
March	48
April	59
May	72
June	83,75
July	84,8
Auguſt	83
Sept.	63
Octob.	52
Nov.	41
Dec.	27

The temperature of the Atlantic under this parallel is 62, but the ſtandard of this part of the globe is the North Pacific, which is here 4 or 5 degrees colder than the Atlantic. The Yellow Sea is the neareſt to Pekin, being about 200 miles diſtant from it; but it is itſelf cooled by the mountainous country of Corea, which interpoſes between it and the ocean, for a conſiderable part of its extent. Beſides, all the northern parts of China (in which Pekin lies) muſt be cooled by the vicinity of the mountains of Chineſe Tartary, among which the cold is ſaid to be exceſſive.

The greateſt cold uſually experienced during this period, was 5°, the greateſt heat, 98°: on the 25th of July 1773, the heat aroſe to 108° and 110°; a N. E. or N. W. wind produces the greateſt cold, a S. or S. W. or S. E. the greateſt heat *.

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* 6 Mem. Sçav. Etrang. p. 528.

Algiers,

Algiers, lat. 36° 49′, long. 2° 17′ E.

The temperature of Algiers was obſerved during 2 years by Mr. Taitebout, by means of a thermometer of Reaumur imperfectly graduated. The obſervations are recorded in the Paris Memoirs for 1735, and the mean was thence deduced by Mr. Wargentin; by his computation it appears to be 72 degrees.

Jan.	62°7
Feb.	61,5
March	63,8
April	67
May	72,8
June	77,5
July	82,6
Auguſt	84,3
Sept.	81,2
Octob.	77,5
Nov.	70,2
Dec.	63,4

The ſtandard temperature is 65°, the difference is 7°; though I cannot venture to ſay that the temperature of Algiers is ſo much higher than that of the ſtandard; yet it probably is 3 or 4 degrees higher, as it has the Mediterranean, which is much warmer than the ſtandard, on the north, and the ſtill warmer tracts of Barbary on its ſouth *. It very ſeldom rains here in Summer, which renders the heat ſtill more conſiderable.

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* Mem. Stock. 1758.

Madeira,

Madeira, Funchall, lat. 32° 37′, long. 17°.

The annual temperature, by obſervations of 4 years, was 68°,6; that of the ſtandard 68°,9 *.

Jan.	64°18
Feb.	64,3
March	65,8
April	65,5
May	66,53
June	69,74
July	73,45
Auguſt	75,02
Sept.	75,76
Octob.	72,5
Nov.	69,08
Dec.	65,

Thibet, lat. 32° and 30°.

This country being very diſtant from the ſea, and formed by the union of very high mountains, is exceeding cold, in ſo much that the thermometer in Winter is often at 3°, and the froſt laſts until the middle of April †.

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* Phil. Tranſ. 1752, and 54. † Ibid. An. 1777, p. 471.

Grand

Grand Cairo, lat. 30°, long. 31° 23 E.

The only obſervations I have met with on the temperature of this city, are thoſe of Mr. Niebur*, and theſe are very imperfect. As far as I can collect from them, the mean of the year 1762 was 75°,9 which is about 5 degrees above that of the ſtandard. That it ſhould be higher, we may eaſily infer from its ſituation, having the Mediterranean on its north, and the ſtony deſarts of Arabia on the eaſt; but the climate is ſubject to great inequalities, for the mean of the year 1761 was but 71°,4.

	Mean		Greateſt Heat.
Jan.	57°	-	69°
Feb.	63	-	73
March	69	-	86
April	72	-	87
May	77	-	96
June	82	-	101
July	88	-	101
Auguſt	87	-	99
Sept.	80	as I ſuppoſe	
October	77		
Novem.	81	-	90
Decem.	66		

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* Voy. Vol. I.

Canton, lat. 23°, long. 113° E.

By the accurate obſervations of Mr. Raper during the year 1774, its temperature was 75°,14; ſtandard temperature 75°,4*.

		Greateſt Heat.	Leaſt.
Jan.	60,47	66,5	51
Feb.	67,44		
March	69,5		
April	74,6		
May	79,82		
June	82,48		
July	84,84		
Auguſt	86,11	89	80
Sept.	85,20		
Octob.	76,91		
Nov.	71,44		
Dec.	62,88		

Mexico, lat. 19° 54′, long. 100 W.

This city is ſaid to ſtand 5491 feet above the level of the Pacific Ocean, midway between it and the Gulph of Mexico. It is ſurrounded by mountains at the diſtance of about 100 miles; its annual temperature is not as yet well known, but probably differs but a few degrees from that of Quito. The few obſervations made here during the year 1769, were made public by Pere La Cotte; they may ſerve to give ſome idea of this climate*.

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* MS. Journal at the Houſe of the Royal Society.

	Greateſt Heat.	Leaſt.
April	74°	53
May	75	51
June	72	56
July	71	50
Auguſt	70	54
Sept.	70	50
Octob.	70	48
Nov.	68	47
Dec.	66	46

Hence it appears, that the temperature of Mexico differs but little from that of Quito. The winds are here pretty conſtant, and ſometimes impetuous, but it rains very ſeldom.

Tivoli in St. Domingo, lat. 19°.

Its mean temperature during the year 1779 was 74°†.

Jan.	69°12
Feb.	68,9
March	71,6
April	73,4
May	72,5
June	78,12
July	77,9
Auguſt	77,02
Sept.	77

The ſtandard temperature is 78°,3, but the elevation of Tivoli is conſiderable, as the mean height of the barometer, during 2 years, was 28,27 inches. According to the eſtimation of Dr. Blagden, which ſeems to me very probable, the mean heat of the coaſt both

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* Meteorol. p. 337.

† Mem. Societ. de Med. 1779.

Oct.	74,75
Nov.	73,62
Dec.	70,92

of this iſland and Jamaica is nearly 81°[*]; at *Cape François* the heat in May and June is generally from 85° to 95° by day, and about 80° by night [†].

Senegambia, lat. 16°, long. 16° W.

The mean heat is 80°, the temperature of the coldeſt months 70°; it ſeldom riſes above 94°, or falls below 64 [‡]; the ſtandard temperature is 79,9.

Senegal, lat. 15° 53,′ long. 16° 26′.

According to Adanſon, the air in the ſhade is moſtly heated to 94°; on the road from Senegal to Podor it is frequently at 111° by day, and 86 at night; in Nigritia the ſand is heated to 140°.

Manilla, lat. 14° 36′, long. 120° 58′ E.

By Mr. Gentil's account, the mean temperature of this town, ſeems to be 78°,4; tha of the ſtandard 80°,4; the cold produced by evaporation, after the great rains, renders many of the intertropical iſlands, ſomewhat cooler than the ſea.

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[*] Phil. Tranſ. 1781, p. 337.
[†] Mem. Par. 1770, p. 679.
[‡] Phil. Tranſ. 1780.

Jan.	70°
Feb.	68
March	72
April	75
May	75
June	87
July	87
Auguſt	87
Sept.	84
Oct.	84
Nov.	82
Dec.	70

Fort St. George, lat. 13°, long. 87° E.

From the beginning of March 1777, to the end of February, 1778, the temperature of this coaſt was upon a mean, 81°,4; that of the ſtandard is 81°,3; the greateſt heat was 102°, the leaſt 64°.

Jan.	73°
Feb.	76,5
March	77
April	80,5
May	88
June	89,5
July	87
Auguſt	86,5
Sept.	83,5
Oct.	82
Nov.	75
Dec.	76,5

Ponticherry, lat. 12°, long. 67°.

The temperature of this town, as obſerved by Mr. Coſſigny, and calculated by Mr. Wargentin, is 88°; the account given of it, by Mr. Gentil, agrees very well with this reſult; it ſurpaſſes the ſtandard by 7 degrees, which is owing to the ſands that ſurround it.

Jan.	79°7
Feb.	83
March	88
April	91,5
May	94
June	95,4
July	93,8
Aug.	92
Sept.	89,5
Oct.	85
Nov.	81,2
Dec.	80,3

Mr. Gentil remarked, that during the greater part of May, June, July, and Auguſt, the heat was 113° or 115°, even at the height of 30 feet, in day time, and 82 at night; and that in April, it was generally from 88 to 93°.

CHAP. XIII.

Of the Temperature of Places, ſituated in the Southern Hemiſphere.

Falkland Iſlands, lat. 51°, long. 66° W.

THESE iſlands lie about 240 miles E. of the continent of America; their temperature, during part of the year 1776, and part of 1777, was 47°,4 [*], which is 5 below the ſtandard; but the deficiency occurs chiefly in the Summer months.

Jan.	56°
Feb.	54
March	51,61
April	48,65
May	46,64
June	43,5
July	37,41
Auguſt	38,64
Sept.	45,75
Oct.	47,51
Nov.	47,2
Dec.	49,87

Here it is evident, that the months of June, July, and Auguſt, which anſwer to our December, January, and February; are all, except Auguſt, rather warmer than the correſponding months at London.

I have allowed the mean of January two degrees more than authorized by the table, as the firſt 19 days, which ſhould be the warmeſt, are omitted in the Journal.

Cape of Good Hope, lat. 33° 55′, long. 18° 28′ E.

During the Winter months, May, June, and July; the mean temperature ſeems to be from 45° to 55; the heat ſcarcely exceeds 64°, and ſeldom falls ſo low as 34°: in Summer, the thermometer is generally between 70° and 80°, and ſometimes between 80° and

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[*] Dalrymple's Voy.

90°, but ſcarce ever exceeds 95°; the S. E. wind is the coldeſt *.

Quito, in Peru, lat. 0 13′, long. 77° 50′ W.

According to Bouguer, this city is ſituated about 130 miles from the Pacific Ocean; its temperature is conſtantly from 63° to 66°; that of the ſtandard is 84°; but the elevation of Quito is 9240 feet, which by the rule chap. 5, lowers its annual temperature down to 61 degrees, which probably is the true mean, as Mr. Bouguer does not ſeem to have kept a regular journal: the mean temperature of the coaſt is about 85°, for by day, the heat is from 90° to 96°, and by night, from 75° to 79°.

On the ſummit of Pinchinca, elevated 5760 feet above Quito, the temperature varies 38°; that is, from a few degrees under congelation, at night, to 63 or 65° at mid-day, when the thermometer is expoſed to the ſun; but, as the thermometer had, moſt probably, a metallic ſcale fixed to it, we muſt abate the temperature, at leaſt, 10 degrees †.

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* 1 Sparm. 112. Mem. Par. 1751. p. 447. † Bouguer Figure de la Terre.

CHAP. XIV.

General Obſervations, and Inferences.

IN the firſt place, we may obſerve, that the month of January is the coldeſt in every latitude.

2dly. That July is the warmeſt month in all latitudes above 48°; but in lower latitudes, Auguſt is generally the warmeſt.

3dly. That December and January, and alſo June and July, differ but little. In latitudes above 30°, the months of Auguſt, September, October, and November, differ more from each other, than thoſe of February, March, April, and May. In latitudes under 30°, the difference is not ſo great. The temperature of April approaches more, every where, to the annual temperature, than that of any other month: whence we may infer, that the effects of natural cauſes, that operate gradually over a large extent, do not arrive at their *maximum*, until the activity of the cauſes begins to diminiſh; this appears alſo in the operation of the moon on ſeas, which produces tides; but after theſe effects have arrived at their *maximum*, the decrements are more rapid, than the increments originally were, during the progreſs to that *maximum*.

4thly. That the differences, between the hotteſt and coldeſt months, within 20° degrees of the equator, are inconſiderable, except in ſome peculiar ſituations; but that they increaſe in proportion, as we recede from the equator.

5thly. That in the higheſt latitudes, we often meet with a heat of 75 or 80 degrees; and particularly, in latitudes 59 and 60, the heat of July is frequently greater, than in latitude 51°.

6thly. That every habitable latitude enjoys a heat of 60 degrees at leaſt, for two months; which heat ſeems neceſſary, for the growth and maturity of corn. The quickneſs of vegetation in the higher latitudes, proceeds from the duration of the ſun over the horizon. Rain is little wanted, as the earth is ſufficiently moiſtened by the liquefaction of the ſnow, that covers it during the Winter; in all this, we cannot ſufficiently admire the wiſe diſpoſition of Providence.

7thly. It is owing to the ſame provident hand, that the globe of the earth is interſected with ſeas and mountains, in a manner, that on its firſt appearance, ſeems altogether irregular and fortuitous; preſenting to the eye of ignorance, the view of an immenſe ruin: but when the effects of theſe ſeeming irregularities, on the face of the globe, are carefully inſpected, they are found moſt beneficial, and even neceſſary to the welfare of its inhabitants; for, to ſay nothing of the advantages of trade and commerce, which could not exiſt without theſe ſeas; we have ſeen, that it is by their vicinity, that the cold of the higher latitudes is moderated, and the heat of the lower. It is by the want of ſeas, that the interior parts of Aſia, as Siberia and Great Tartary, as well as thoſe of Africa, are rendered almoſt uninhabitable; a circumſtance which furniſhes a ſtrong prejudice againſt the opinion of thoſe, who think theſe countries were the original habitations of man. In the ſame manner, mountains are neceſſary; not only as the reſervoirs of rivers, but as a defence againſt the violence of heat, in the warm latitudes: without the Alps, Pyrenees, Apennine, the mountains of Dauphine, and Auvergne, &c. Italy, Spain, and France would be deprived of the mild temperature, they at preſent enjoy. Without the Balgate hills, or Indian Apennine, India would have been a deſart. Hence, Jamaica, St. Domingo, Sumatra, and moſt other intertropical iſlands, are furniſhed with mountains, from which the breezes proceed that refreſh them.

8thly. We may obſerve, why grapes do not come to perfection in the neighbourhood of London, as they do in that of Paris, though the annual heat be nearly the ſame, and the Winters are rather milder at London; for by the tables of the monthly temperatures of both, we find, that from the beginning of April, to the end of October, the heat is greater at

Paris; and thus we may learn the fitneſs of any climate, for any vegetable: hence we ſee, that vines may thrive, as they actually do, at Aſtracan *.

Laſtly. Since the aſtronomical ſource of heat is permanent, and the local cauſes of its modification undergo no annual variation, and yet the temperature of no two ſucceeding years, is perfectly alike, it is evident, that this annual variation proceeds from cauſes equally variable: of theſe, there may be many, but at preſent, we know of none, that have a demonſtrable influence on the weather, but winds; and ſince winds themſelves, however uncertain in appearance, are like all the other phænomena of nature, governed by fixed and determinate laws, they deſerve the moſt ſerious inveſtigation, for which we are at preſent, tolerably well prepared.

CHAP. XV.

Of the Cauſes of unuſual Cold in Europe.

UNUSUAL cold happens either in the Summer, or in the Winter ſeaſon; the circumſtances, which render Summers leſs warm than uſual, are pretty obvious; for the diminution of heat may ariſe, either from a long continuance of eaſterly or northerly winds, or from frequent and heavy rains, which are followed by great evaporation, or from a long continuation of cloudy weather, in the months of June and July, which prevents the earth from receiving its proper degree of heat.

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* 2 Decouvertes Ruſſes, p. 111.

But the cauſes of unuſual cold in winter, are more remote, and of more difficult inveſtigation; thoſe that I am acquainted with are,

1ſt. *Unuſual cold in the preceding Summer.* For, as the Winter's heat is in great meaſure derived from the earth; if this be deprived of its uſual ſtore of heat, the want of it, muſt be perceived the enſuing Winter; the cold of Jan. 1709, was the ſevereſt, long known in Europe; and Mr. Derham remarked, that the preceding June was ſo cold, that his thermometer was near the freezing point, on the 12th of that month, and the quantity of rain much greater than uſual. * Mr. Wolf made the ſame obſervation, at Halles, in Germany †.

2dly. *Heavy rains followed by eaſterly or northerly winds.* This circumſtance would produce great cold in any ſeaſon, on account of the powerful evaporation, promoted by theſe dry winds; it actually took place, in

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* Phyſ. Theol. Lib. I. cap. 3. † Meletemeta, p. 356.

October, 1708, as Mr. Wolf obſerved; and an intenſe cold immediately followed *.

3dly. *Weſterly or ſoutherly currents, in the upper regions of the atmoſphere, while eaſterly or northerly prevail in the lower.* For the warm currents are in great meaſure deprived of their moiſture, by the cold of the ſuperior regions; and, this deſcending in the form of ſnow, cools the inferior ſtrata, below their uſual temperature: this circumſtance alſo took place in the year 1709, as Mr. Wolf remarks, when the cold was greateſt †. Yet I have often remarked, the weather to become milder after a fall of ſnow; but this happens, chiefly when the wind is weſt or ſouth; for the vapours being then in the lower atmoſphere, warm it by their condenſation.

4thly. *The arrival of Siberian, or American winds.* Siberia is 2800 miles to the eaſt of London; but, according to the computation of Mr. Smeaton, a common high wind moves at the rate of 35 miles an hour; and, therefore, may paſs to us in three days, from Siberia: now Dr. Blagden has ſhewn, that a current of 20 leagues in breadth, and 10 degrees warmer than the ocean, through which it flows, may preſerve four degrees of its heat, after it has traverſed a ſpace of 7 or 800 miles ‡; and Sir Benjamin Thomſon has proved, that air is much a worſe conductor of heat, than water *; therefore, we may well ſuppoſe, that the Siberian winds may preſerve much of their original temperature, on arriving here; particularly if they blow with conſiderable force, and laſt ſome days. America is not ſo diſtant, but weſterly winds may arrive from it, in a few days: it is true, their rigour is much moderated, by paſſing over the ſea; but if the ſurface of the ſea had been previouſly cooled by northerly winds; or, if the weſterly are ſtrong, and of long continuance, they may prove unuſually cold in this country. Mr. Derham, on comparing his journals with thoſe of Mr. Robie, in New England, found, that after a few days, the American winds actually paſſed into England †. The Winter of 1784 was equally ſevere, in America, as in Europe ‡. It ſhould alſo be remarked, that the Siberian winds, if they originate in a lower latitude, will appear S. E. to us; becauſe, finding the atmoſphere of latitudes more northern, leſs cold, they will blow towards that quarter alſo; and if they originate in a latitude, higher than ours, they will appear N. E. as they will be deflected to more ſouthern latitudes, where they meet with leſs reſiſtance; and for the ſame reaſon, the American winds will appear N. W. or S. W.

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* Meletemeta, 326. † Ibid. 357. ‡ Phil. Tranſ. 1781.

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* Phil. Tranſ. 1786. † 6 Phil. Tranſ. Abridg. Part 2. p. 143. ‡ 25 Roz. 465.

5thly. *The fall of a ſuperior ſtratum of the atmoſphere.* This will happen, when a cold wind, in the upper regions of the atmoſphere, paſſes over a country, the lower ſtrata of whoſe atmoſphere, are ſpecifically lighter; and hence a low ſtate of the barometer, generally precedes ſuch extraordinary cold. It is probably, for this reaſon, that Holland oftener experiences a degree of cold, greater than countries, placed under higher latitudes; for Holland being a very moiſt country, its atmoſphere abounds more in vapours, which render it ſpecifically lighter; thus, during the great cold of Jan. 1783, the barometer was lower, than it was known to be for 50 years before, during that month *: and Muſchenbrock remarked, that in Winter, when the mercury in the barometer deſcends, the cold increaſes †.

CHAP. XVI.

Compariſon of the Temperature of London, with that of other noted Places.

THE firſt column exhibits the differences of the annual temperature; the ſecond, that of the month of January, as being generally the coldeſt; and the third, that of

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* 25 Roz. 463. Mem. Berlin, 1782, p. 25. † Muſchenb. p. 120. §. MMLXX.

July; that of London, as the ſtandard, being eſtimated at 1000. The degree of cold, is eſtimated in the ſecond column; and the degree of heat, in the firſt and third.

	Annual.	Jan.	July.
London -	1000	1000	1000
Paris - -	1028	1040	1037
Edinburgh -	923	1940	914
Berlin - -	942		
Stockholm -	811	1583	964
Peterſburgh -	746	3590	1008
Vienna - -	987	1305	1037
Pekin - -	1067	1730	1283
Bourdeaux -	1090	925	1139
Montpelier -	1170	850	1196
Madeira - -	1319	559	1128
Spaniſh Town, in Jamaica -	1557		
Madraſs -	1565	491	1349

FINIS.

A View of the annual Temperature of the different Places mentioned in this Eſſay, according to the Order of their Latitudes.

	North Lat. deg. m.	Longitude. deg. m.	Mean Annual Heat.
Wadſo, in Lapland,	70°5′		36°
Abo,	60,27	22,18 E.	40,
Peterſburgh,	59,56	30,24 E.	38,8
Upſal,	59,51	17,47 E.	41,88
Stockholm,	59,20	18, E.	42,39
Solyſkamſki,	59,	54, E.	36,2
Edinburgh,	55,57	3, W.	47,7
Francker,	53,	5,42 E.	52,6
Berlin,	52,32	13,31 E.	49,
Lyndon, in Rutland,	52,30	0, 3 W.	48,03
Leyden,	52,10	4,32 E.	52,25
London,	51,31		51,9
Dunkirk,	51,02	2, 7 E.	54,9
Manheim,	49,27	9, 2 E.	51,5
Rouen,	49,26	1, W.	51,
Ratiſbon,	48,56	12,05 E.	49,35
Paris,	48,50	2,25 E.	52,
Troyes, in Champaigne,	48,18	4,10 E.	53,17
Vienna,	48,12	16,22 E.	51,53
Dijon,	47,19	4,57 E.	52,8
Nantes,	47,13	1,28 E.	55,53
Poitiers,	46,39	0,30 E.	53,8
Lauſanne,	46,31	6,50 E.	48,87
Padua,	45,23	12, E.	52,2
Rhodez, in Guienne,	45,21	2,39 E.	52,9
Bordeaux,	44,50	0,36 W.	57,6
Montpelier,	43,36	3,73 E.	60,87
Marſeilles,	43,19	5,27 E.	61,8
Mont Louis, in Rouſillon,	42,	2,40 E.	44,5
Cambridge, in New England,	42,25	71, W.	50,3
Philadelphia,	39,56	75,09 W.	52,5
Pekin,	39,54	116,29 W.	55,5
Algiers,	36,49	2,17 E.	72,
Grand Cairo,	30,	31,23 E.	73,

Canton,

	North Lat. deg. m.	Longitude. deg. m.	Mean Annual Heat.
Canton, - -	23,	113, E.	75,14
Tivoli, in St. Domingo,	19,		74,
Spaniſh Town, in Jamaica,	18,15	76,38 W.	81,
Manilla, - -	14,36	120,58 E.	78,4
Fort St. George, -	13,	87, E.	81,3
Ponticherry, -	12,	67, E.	88,
	South Lat.		
Falkland Iſlands, -	51,	66, W.	47,4
Quito, - -	0,13	77,50 W.	62,

ERRATA.

P. 18, line 13, for 62,1, *read* 62.
P. 18, line 21 and 23, for 62,1, *read* 62.
P. 20, line 7, for ſun's altitude, *read* ſun's mean altitude.

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